THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 44 DECEMBER, 1940 No. 6

THE ROENTGEN KYMOGRAPHIC EVALUATION OF THE SIZE AND FUNCTION OF THE HEART*

By ANCEL KEYS, H. L. FRIEDELL, L. H. GARLAND, M. F. MADRAZO, *and* LEO G. RIGLER

From the Laboratory of Physiological Hygiene and the Department of Radiology, University of Minnesota, Minneapolis; the Stanford Radiology Section, San Francisco Hospital, San Francisco; and the Hospital de los Ferrocarriles, Mexico City, Mexico.

Introduction

IT IS agreed that the heart has only one function—to pump the blood—but the fact remains that the great majority of all studies on the heart in the intact body have but indirect and often only remote relation to that function. The pumping activity of the heart is a mechanical function involving contraction of a relatively radiopaque organ in a relatively radiotranslucent field. It may be surprising, therefore, that critical attempts to use radiological methods for the estimation of functional activity of the heart have been so few. Technical difficulties in registering cardiac contraction, the complex nature of the motions involved and the persistence of emphasis on the purely morphological as contrasted with the physiological problem have been responsible. The purpose of the present study is to analyze the technical difficulties, and to emphasize the physiological possibilities of cardiac roentgenography.

The health or disease of the heart, in the long run at least, must be assessed in terms of the amount of blood it supplies to the tissues of the body and to itself. The growing recognition of this fact is reflected in the numerous recent papers dealing with the stroke output or minute volume of the heart. The subject has been reviewed by Grollman (1932), Christensen (1937) and Lequime (1940), all of whom emphasize the utility of the acetylene rebreathing procedure. These studies, as well as those by Grollman, *et al.* (1933), Gladstone (1935), McGuire, *et al.* (1937), Stewart, *et al.* (1938), make it clear that the acetylene method, though rather difficult and not always applicable, is at present the best standard of comparison by which to evaluate any roentgenological methods for the estimation of stroke output.

We have recently shown that calculations from measurements of frontal plane areas at systole and at diastole in roentgen kymograms can give results closely approximating those obtained with the acetylene method (Keys and Friedell, 1939). These results were so promising that we have devoted the past year to an intensive critical application of these procedures with the assistance and collaboration of a number of other investigators in four separate laboratories.†

† For facilities we are greatly obligated to Dr. J. C. Geiger, Director of Public Health, San Francisco, Mr. Ray Amberg, Superintendent of the University of Minnesota Hospital, Minneapolis; and to Dr. A. Mongez Lopez, Chief of Staff of the Hospi-

* Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

The multiple slit roentgen kymograph of Stumpf (1928, Stumpf, Weber and Weltz, 1936) makes it possible to trace the outlines of the heart in successive systoles and diastoles. The possibility of application of the roentgen kymograph to the study of the stroke output of the heart was appreciated by Johnson (1937) and by de Abreu (1939), both of whom devised "indices" of cardiac activity. Ungerleider and Gubner (1939) have suggested that the roentgen kymograph might be used to measure the velocity of propagation of the pulse wave for use in Broemser and Ranke's (1930) method of estimating the stroke output.

Material

The basis of this report consists of several hundred roentgen kymographic studies, controlled by the acetylene method, carried out on subjects judged free from valvular disease, congenital and other structural defects of the heart. In addition, roentgen kymograms without acetylene output controls were available on an additional 500 subjects. For the most part we used volunteers or hired subjects between eighteen and forty years of age, but subjects as young as twelve and as old as sixty were used. Most of the subjects were "normal" in all respects, but patients with hyperthyroidism, myxedema, moderate hypertension, fractures, and angina pectoris were also studied. Three-fourths of the subjects were males. In all cases a dummy trial experiment was carried out as training before the actual experiment to ensure the necessary cooperation in the acetylene rebreathing.

Procedure

In the principal experimental series the subject came to the roentgen laboratory (in most cases in the fasting state) and sat quietly in a special revolving chair during the entire procedure. After a rest of fifteen to thirty minutes, oxygen consumption was measured with a recording metabolism machine. The first roentgen kymogram was then made, followed immediately by the acetylene rebreathing and then a second roentgen kymogram. In some cases the entire series of measurements was repeated within thirty minutes to an hour or so. Pulse rates were counted almost continuously during the period of several minutes in which the kymograms and the rebreathing were done.

In about half the experiments the 3-sample acetylene procedure (Grollman, *et al.*, 1933) was followed. After special study showed this to have no advantage and some disadvantage in this work, we reverted to the original 2-sample technique. Gas analyses were made in duplicate by separate analysts on different machines.

All kymograms were made in the postero-anterior position at a film-to-target distance of 66 inches, and the calculations were corrected for triangular distortion. In many cases lateral films were made to get the heart-to-film distance for this correction. In the others this distance was estimated as one-third of the anteroposterior chest diameter as measured with a pelvimeter plus the distance from the outside of the kymograph panel to the film. This latter calculation was proved to be entirely satisfactory by numerous duplicate trials. The correction for triangular distortion amounts to 10 to 15 per cent of the projected heart area under these conditions. Exposure times of one to three seconds were used. Three different roentgen kymographs were used in this work. In two of the machines the grid spacing was 10 mm. and the slit width was about 1 mm.; in the third machine the grid spacing was 12 mm. and the slit width was 0.4 mm. No differences in results with the different machines were noted.

Diastolic and Systolic Heart Outlines

The diastolic and systolic outlines were drawn directly on the films with a soft,

tal de los Ferrocarriles, Mexico City. Much assistance was given by Dr. J. H. Haworth and Mr. Henry Longstreet Taylor in San Francisco and Dr. Antonio Violante in Mexico City. Invaluable clinical cooperation was afforded by Drs. Phillip Hallock and M. J. Shapiro in Minneapolis, Drs. William Dock, W. J. Kerr, A. C. McKenney, J. Marion Read and others in San Francisco, and Dr. Salvador Garcia-Tellez in Mexico City.

sharp pencil. These outlines are easily removed with a soft eraser and leave no mark visible when the film is in the viewing box, so duplicate drawings were frequently made by different persons and by different techniques.

The general procedure was to trace first the diastolic and systolic outlines of the left and right (in that order) margins of the heart shadow, taking the extreme outer margin of a particularly clear cardiac cycle in the left ventricle as the point of reference. The upper and lower borders were completed by a procedure similar to that used by Bardeen (1918). The systolic outlines for the left and right sides were next drawn, the upper and lower borders being common to both systole and diastole. Since these upper and lower borders approach the horizontal, i.e., parallel to the grid lines of the kymogram, very little motion could be recorded even if it were possible to visualize these regions of uncertainty. In all cases the systole immediately following the diastolic point of reference was taken as the reference moment of systole for the whole heart.

The necessary conventions for making such drawings must be considered in detail. The point of departure for this work was the posteroanterior projection area—volume relation obtained from studies on cadavers (Keys and Friedell[35]). In those studies the roots of the great vessels were included in the measured heart volume and the drawings on the films from the cadavers were made accordingly. In the drawings on the kymograms from the living subject we attempted, in general, to reproduce as accurately as possible the method used on the cadavers but, of course, special conventions had to be developed for the kymograms.

Two sets of conventions, or methods of drawing the heart outlines, were finally developed for the kymograms from the living subject. These give rather different numerical results which will be discussed later in this paper. Method *A* gives the larger excursion and a slightly larger total size of the heart. It requires more skill but, when used by a person with much experience, it yields somewhat more consistent results than Method *B* in which the conventions are more arbitrary. The two methods differ in the placement of the systolic outline and in the location of the apical and basal margins.

In Method *A* the systolic outline is drawn as centrally as possible and on the left side of the heart the line of systole follows the curves of the base and the apex to join the diastolic outline more or less asymptotically. The completion of the outline from the apex to the right side of the heart is made with a generous curve approximating, on the basis of experience, the true position of the caudad margin of the heart. The outline at the base of the heart includes the cardiovascular shadow to the frame immediately below the first frame showing pulsations that are definitely arterial, i.e., extracardiac, in phase. The outline of the base is completed by a smooth curve extending upward about half a frame in conformity with the natural curve of the heart margin at this point.

In Method *B* the systolic outline is drawn through the most central point of *maximum contrast* between the "valley" of systole and the "hill" of diastole. The systolic outline is joined to the diastolic outline at the base and at the apex with the shortest smooth curve that can be drawn. In Method *B* the completion of the outline at the apex is made with as short a curve as possible and a similar convention is used at the base. The outline of the base is carried around the most cephalad frame which shows pulsations of definitely ventricular type or in which the ventricular component is very prominent.

In both methods it is essential to connect points at exactly the same moment in each frame. A particularly sharp diastole on the left ventricular border is selected as the reference point. A pair of fine dividers with a screw adjustment is set at the distance from a grid line to this reference diastole and the time of the diastolic points in each grid frame are checked by the dividers as they are drawn. The same procedure is applied to systole, the systolic reference al-

ways being the systole immediately following the reference diastole. When this is done it will be noted that the moment of left ventricular systole usually corresponds to an inward movement of the right auricle but not to the innermost part of the "valley."

The salient features of the two methods are illustrated in Figures 1 and 2 in which roentgen kymograms of two hearts of very different type are shown together with the tracings made by the two methods. The quantitative difference in results obtained by the two methods is discussed later in this paper.

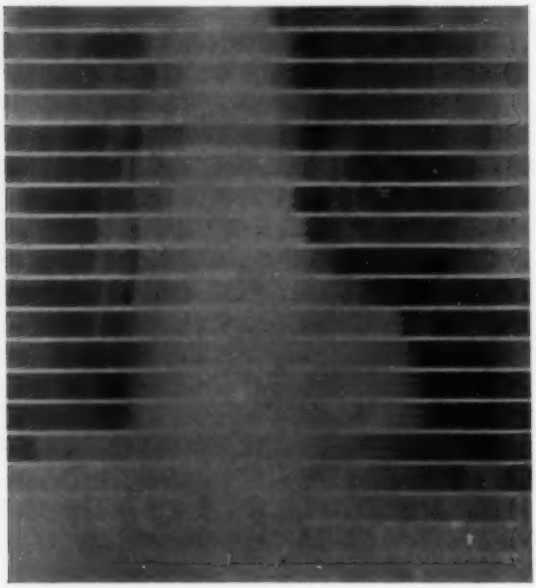
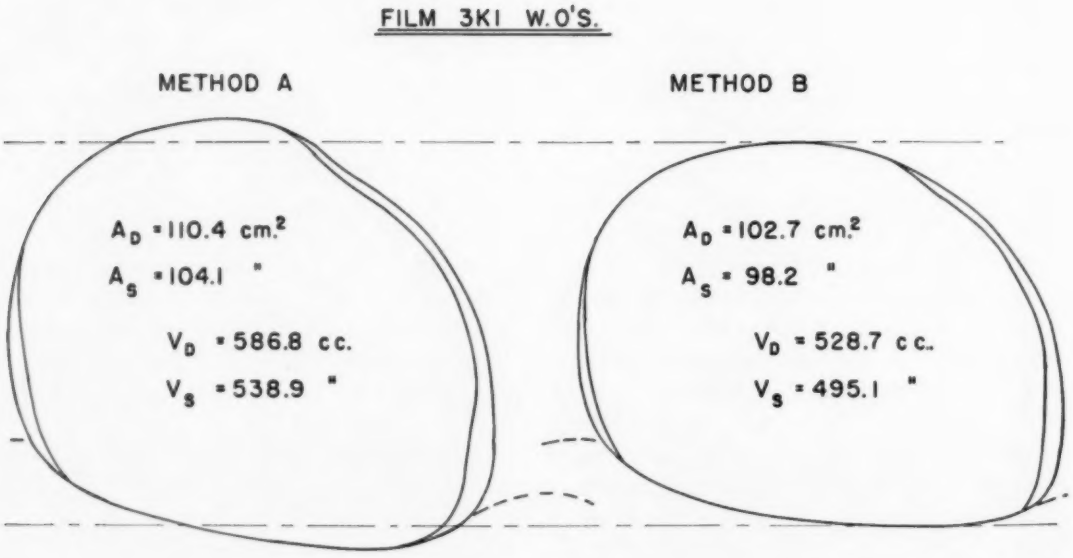


FIG. 1. Roentgen kymogram of a normal male aged thirty-nine. The systolic and diastolic outlines are drawn by Methods *A* and *B*, and are shown together with the measured areas and the calculated volumes. Note that by Method *A*, $\Delta V = 586.8 - 538.9 = 47.9$ cc., while by Method *B*, $\Delta V = 33.6$. The ratio $\Delta V_A / \Delta V_B = 1.43$.



Movements of the Heart in the Cardiac Cycle

The kymogram records displacements of the cardiac periphery which are the resultant of a number of movements in addition to the simple volume diminution of ventricular contraction. It has long been known

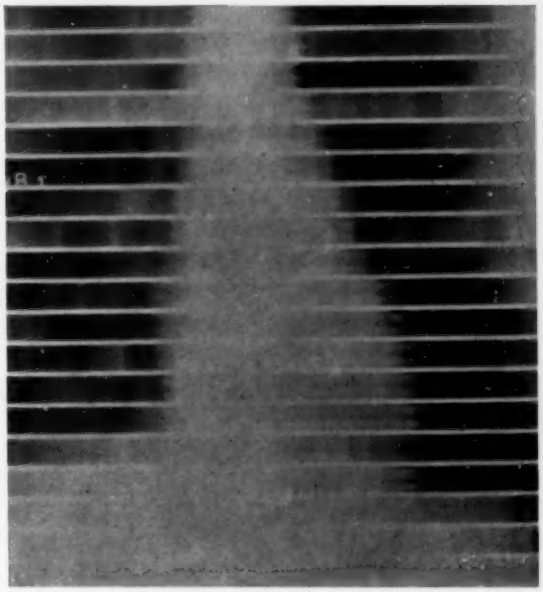
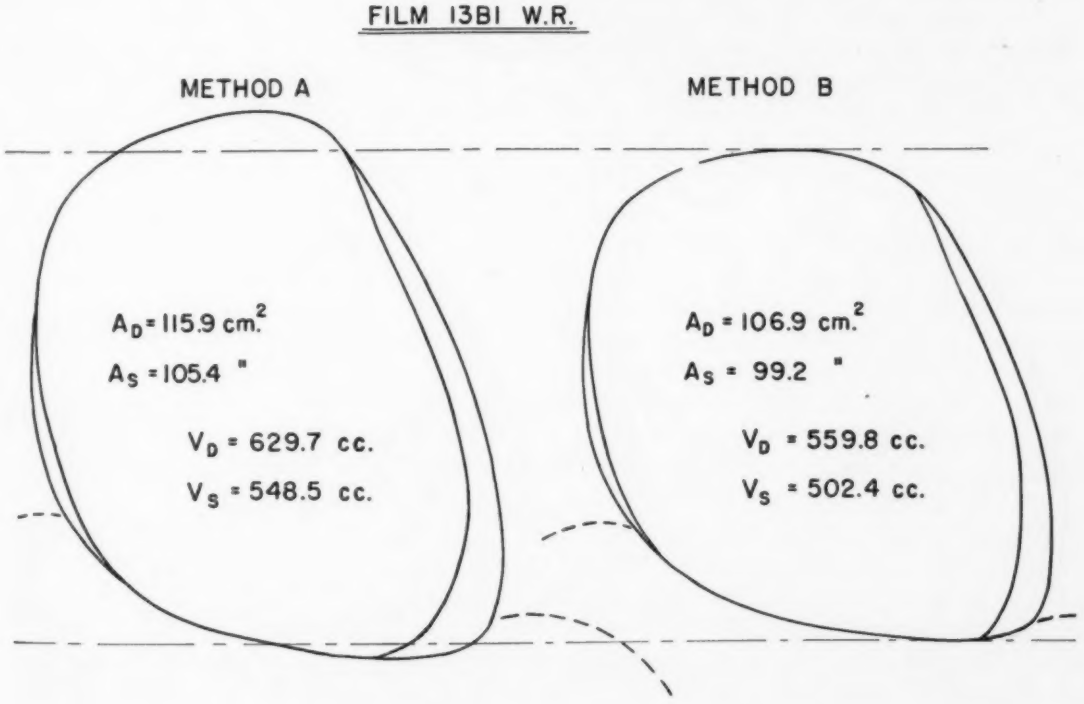


FIG. 2. Kymogram of an athlete, aged twenty-one. By Method *A*, $\Delta V = 81.2$, and by Method *B*, $\Delta V = 57.4$ cc. The ratio $\Delta V_A/\Delta V_B = 1.41$.



that the center of mass of the heart shifts during contraction (Groedel, 1912) and other movements have recently been discussed in detail by Brednow and Schaare (1933), Ludwig (1938) and Franklin (1939). Such movements are necessitated by the spiral arrangement of the muscle fasciculi (cf. Tigerstedt, 1921, Wiggers, 1923) and the recoil of the heart from the pressure release on the ejection of blood (Henderson, 1905). Lateral pendulum motion may be prominent in the asthenic type of individual (Heckmann, 1937).

The principal components which may be

involved in the total resultant movement of the cardiac periphery are: (1) the cardiac contraction proper; (2) rotation of the heart about its long axis; (3) lateral pendulum and rocking motion; (4) anteroposterior pendulum and rocking motion, and (5) displacement of the atria by internal stress transmitted by way of the septum intermedium and the tricuspid and mitral valves.

Given adequate data on these various movements it would be possible, though tedious, to synthesize geometrically the resultant movements which would be recorded by the kymogram. The reverse quantitative analysis does not seem to be possible (Stumpf, Weber and Weltz, 1936; Heckmann, 1937). At best only a partial dissociation may be made between the action potentials, recoil of contraction and the time course of changes in the cardiac periphery (simultaneous roentgen kymograms, electrocardiograms, and cardiac recoil records, Westermark, 1936).

These facts do not prevent a comparison of the magnitude of the total resultant changes with the cardiac output as estimated by the acetylene or another acceptable method. The largest changes in the cardiac periphery are those of the volume contraction itself. When the area of the posteroanterior projection is measured at definite moments, lateral pendulum and rocking motion is automatically compensated. For example, if the whole heart swings toward the right in synchrony with the ventricular systole and back again during diastole the excursion of the left side of the heart in the cardiac cycle will be greater than the true contraction excursion. On the other hand, the excursion of the right side of the heart will be diminished by an equal amount. It is easy to demonstrate this point by making a kymogram of a preserved heart or a lead disc suspended so as to swing in slight pendulum motion. The resultant film shows a notched contour simulating contraction at first sight, but when the outlines of "diastole" and "systole" are drawn by the method of fixed moments of time they prove to have equal areas and this area is the same as that of the still projection.

Such simple experiments show the dangers of confining measurements to one side of the heart and points the fact that it is unjustifiable to draw conclusions about the relative activity of different parts of the heart from the apparent contractions on the two sides. We have observed kymograms in which the projection outline of the right side of the heart in the posteroanterior view at the moment of left ventricular systole is outside (to the right) of the outline at the diastolic moment. In these cases the pendulum motion is greater than the ventricular contraction motion which is ordinarily transmitted to the right side.

In the posteroanterior view the adventitious posteroanterior motions are not recorded. Any other changes are directly consequential to the cardiac contraction and might be expected to bear some relatively constant relation to it in the absence of abnormal distorting forces—pericardial adhesions, calcification, pneumothorax, neoplasms, etc. That the foregoing argument is valid is abundantly proved by the data given in this paper.

It should be noted that movements of the septum intermedium and valve areas (floor of the atria) undoubtedly take place (Wolferth and Margolies, 1939; Stumpf, 1939) but they do not create any special difficulty. In effect, such movements resolve themselves into movements of the whole heart, and therefore do not differ from pendulum or rocking movements, though they could produce errors if measurements were confined to one side of the heart.

Some arguments based on these septal movements are naive. In the first place statements that the pull on the septum during ventricular contraction must create a "powerful suction" in the auricles fly in the face of innumerable physiological observations extending over many years. Secondly, it should be remembered that "cardiometers," which record plethysmographically the volume change of the external ventricu-

lar portion of the heart, are universally used in physiological laboratories to measure stroke output and this usage is justified on the basis, again, of innumerable controlled observations extending over many years (cf. e.g., Wiggers, 1928).

Variations in the proportion of ventricular contraction motion occurring in the lateral and in the posteroanterior planes will, of course, lead to error and it is probable that the chief inconstancy in the results recorded in this paper derive from this source. Larger errors would be expected in definitely abnormal hearts, especially where great disporportion exists between different chambers of the heart. However, such abnormalities as are associated with hyper- and hypothyroidism, and with hypertension have not been disturbing in the cases of these types which we have studied with both kymograms and acetylene. Valvular heart disease is another matter which will be discussed briefly in a separate section.

Technique for Roentgen Kymographic Studies

Stumpf, Weber and Weltz (1936) discussed the technical problems involved in making satisfactory exposures with the multiple slit roentgen kymograph. Several important points have been clarified by the densitometric studies of Schroderer (1938) who showed that as the film-target distance is increased the sharpness of the kymogram increases to a maximum at 120 cm., beyond which no further improvements result and no measurable effect on sharpness occurred when the exposure time was varied from two to six seconds. At distances greater than about 120 cm., Schroderer found no improvement in the use of a fine focus tube as compared with a tube with a focal spot of 4.1 mm. diameter. Our experience is in entire agreement with that reported by Schroderer and we were unable to detect any difference in quality of kymograms made at 66 inches with times from 1.2 to 5 seconds and with tubes having focal spots from 2.3 to 5 mm. diameter. We have already indicated our finding that reduction of the slit width of the kymographic apparatus below 1 mm. has little practical advantage in view of the increased intensity of exposure required.

Sufficient exposure is, however, of great importance. At 66 inches it is difficult to overexpose a kymogram intended for study of the heart size and stroke. From time to time we have been forced to discard films because of underexposure but we have rarely spoiled a film by overexposure in over 2,000 roentgenograms. We have carefully studied results with seven different machines, made by five different companies, using a film-to-target distance of 66 inches, a slit width of 0.4 mm. and an exposure time of 1.5 seconds, from which we conclude that most fully rectified installations require 80 to 85 kv. (peak) at 100 ma. for a chest thickness of 15 cm., and from 90 to 95 kv. (peak) for a 20 cm. chest. For a 25 cm. chest about 90 kv. (peak) at 200 ma. will usually suffice. It is, of course, necessary to use high speed screens and film.

Exact time differentiation between diastole and the following systole is best achieved with a maximum distance on the film between them. However, a very wide spacing between slits makes it difficult to reconstruct the heart outlines and, it should be remembered that in any kymogram there is an uncertainty of distance in the direction of the film movement of half the grid spacing. We consider 10 to 12 mm. to be most satisfactory for the grid spacing; with 18 mm. grid spacing the accuracy of the reproduction of the heart outlines was definitely inferior.

Achievement of maximum sharpness in roentgen kymograms requires consideration of certain factors aside from those involved in ordinary roentgenograms. Obliquity unsharpness is proportional to the slit width and to the acuity of the angle between the slit and the contour of the organ. Movement unsharpness is also directly related to the slit width but the rate at which the film emulsion is affected by roentgen rays must be considered also. Movement unsharpness

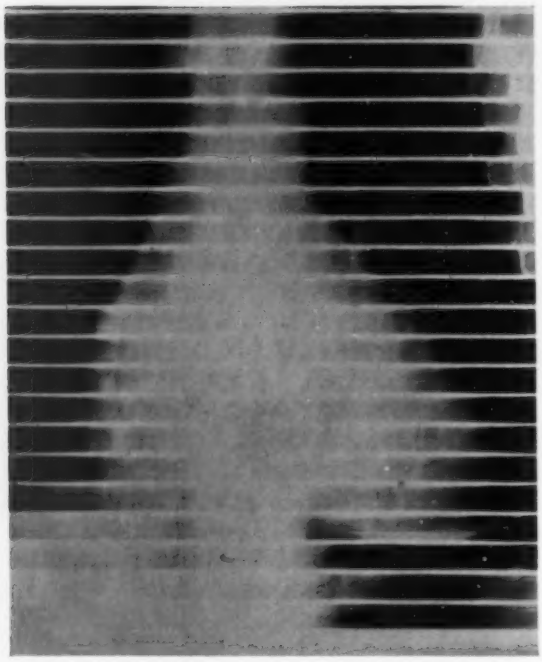


FIG. 3. Kymogram illustrating complete arrhythmia. Note variation of amplitude of pulsation as well as rate. Six cycles are shown in this 4½ second exposure of the heart in a male, aged fifty, with mitral disease.

is reduced somewhat by using what would ordinarily seem to be rather excessive exposure (cf. Schwarzschild, 1939). Both experience and theory show that the maximum sharpness is attained with small slits and heavy exposure. In our experience reduction of slit size below 1 mm. provides little increase in sharpness, and of course the intensity of exposure must be increased according to the decrease in slit width.

It is essential that more than one full cardiac cycle be registered on the film and the best results are achieved with an exposure time which records from one and one-half to two and one-half cycles. If there is marked irregularity in the heart rate, however, no reliance can be placed on the analysis of any single cardiac cycle. A longer exposure time, say four or five seconds, may be used and three or more cycles may be measured separately. Occasionally a heart that is irregular in rate may be regular in the extent of its filling and contraction at each beat but in the great majority of these cases the irregular beats are of unequal magnitude. An example is given in Figure 3 in which a five second exposure was used. A fair estimate can be made of the cardiac output in such cases from the average of a number of cycles made from several films.

In many cases it is useful to have an ordinary teleroentgenogram for comparison with the kymogram and such films were taken on many of the cases used in this

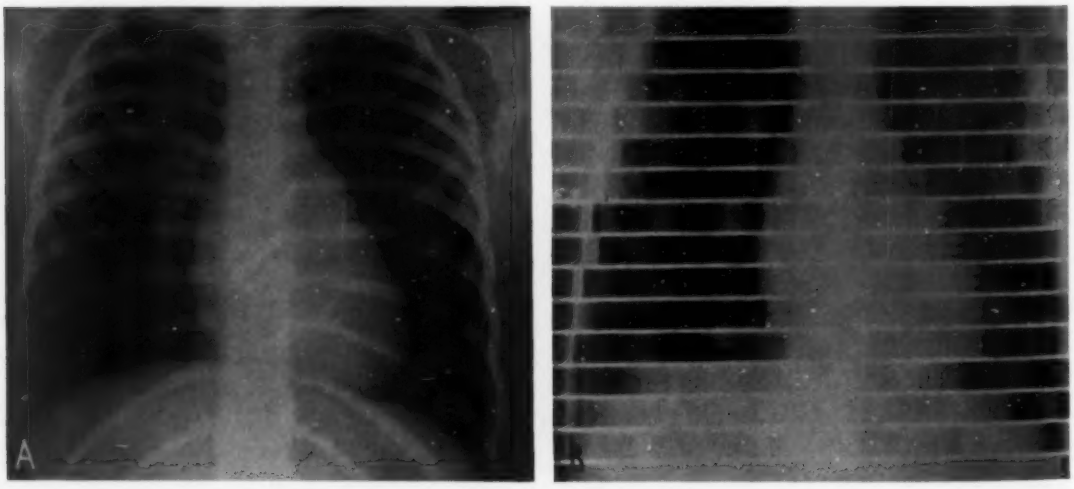


FIG. 4. Illustrating results with the simultaneous still and kymographic technique. M. J. F., girl, aged five, with patent ductus arteriosus. *A*, film exposed for 1½ seconds in a cardboard film holder attached to front panel of kymographic apparatus. *B*, kymogram simultaneously exposed through film *A*.

study. A useful innovation was made at the suggestion of Dr. J. H. Haworth during the work in San Francisco. The lead is removed from the back of an ordinary cardboard holder and this holder, loaded with a film, is fastened to the front of the kymographic apparatus. In this way the kymogram is exposed through the still film and both are exposed. The absence of intensifying screens compensates for the long exposure of the still film and the roentgenographic quality is surprisingly good in view of the fact that several cardiac cycles are superimposed. Lead markers may be used as landmarks so that the two films may be accurately superimposed for study. An example of this technique is given in Figure 4.

Other Kymographic Arrangements

We have used throughout all our work the multiple slit kymograph with the moving film and stationary grid. The reverse arrangement—moving grid and stationary film—is not suitable for such quantitative studies for the reason that in this latter arrangement successive systoles and diastoles are not registered from the same points of the heart. The difference is not a serious source of error where the cardiac border may be exactly vertical (parallel to the film motion) and the magnitude of contraction is uniform, but these conditions only obtain in very limited regions and elsewhere the error is of a large order.

Quantitative analysis of the results with the interrupted slit kymograph (Cignolini, 1934, 1935) would be impossible or at best extraordinarily difficult, owing to the uncertainty as to the components of motion represented on the film in the various frames. The "rotary" or "radial" method of kymography (Lorens, 1937) has the advantage of permitting visualization of movements in all directions, but the magnitude of the recorded motion is dependent on the absolute direction of the cardiac motion and the position of the center of rotation with reference to the contraction center of the heart, neither of which can be determined from the film. Moreover, in order to discover points in the several frames representing the same moment of time it is necessary to measure angles of rotation which is much more difficult than laying off the times as simple linear distances in the ordinary kymogram.

The Heart Volume

The point of departure for the estimation of the stroke volume output of the heart is

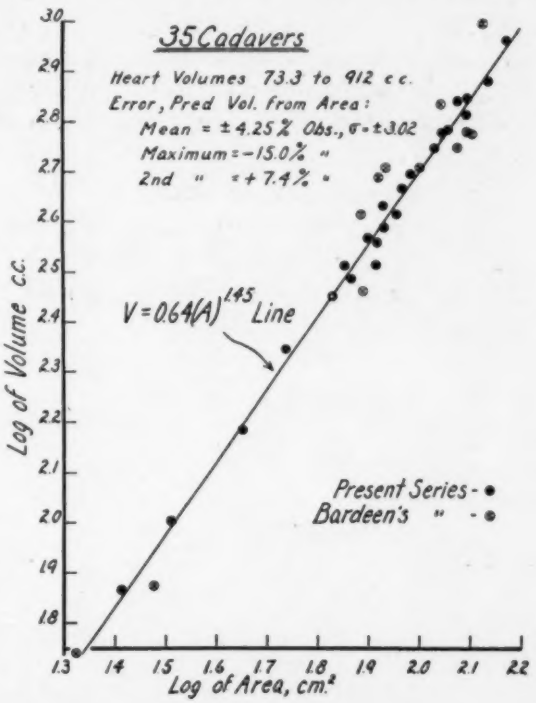


FIG. 5. Relation between frontal projection area (corrected for distortion) and volume of the heart in 35 cadavers.

the fact that this must be related to a volume change of the heart during the expulsion of the blood. It is necessary, then, to appraise the accuracy to be attained in calculating the heart volume from mensuration of a plane projection such as the posteroanterior kymogram. Bardeen (1918) reported gratifying success in predicting the heart volume from the area of the posteroanterior outline of the heart in cadavers with the chest opened (he did not make roentgenograms).

We have already reported briefly the results obtained with 17 cadavers in whom

posteroanterior teleroentgenograms were made before the chest was opened (Keys and Friedell[35]). This series has been extended and it has been possible also to recalculate and so obtain the original data for some of Bardeen's cadavers. The results for the total of 35 cadavers are summarized in Figure 5.

In our original series of 17 cases we began our analysis by considering the heart to represent any combination of ellipsoids, spheroids, or other geometrical forms. Hence the relation between projection area and volume must be of the general exponential form:

$$\text{Volume} = \text{constant} \times (\text{area})^{\text{exponent}}.$$

The linearity of the logarithmic plot of volume against area showed this to be true and the solution of the equation by visual fitting was:

$$V = 0.63\ (A)^{1.45}.$$

When the regression line was fitted by the method of least squares the identical equation was obtained. The best least squares fit for the complete data given in Figure 5 is obtained with practically the same constants:

$$V = 0.64\ (A)^{1.45}.$$

It should be stated that, because of the peculiar form in which Bardeen's results were published, only the most aberrant hearts from his series could be included here; only in those cases was it possible to make the calculations to obtain the necessary original data. Even so, Figure 5 shows that the mean prediction error for the entire series is only ±4.25 per cent, and that, save for a single case in which the error was −15 per cent, the error in predicting the volume from the posteroanterior area was always less than 7.5 per cent.

Reproducibility of Kymographic Drawings

The success attained in estimating heart volume from posteroanterior roentgenograms could be duplicated with kymograms of the living heart only if the heart outlines drawn from kymograms are reproducible. This was tested in a number of ways.

Duplicate drawings were made by the same investigator from five or six kymograms selected at random. In each case the second drawing was made in routine fashion without reference to the first drawing, usually on another day. These drawings were all measured by an independent technician. Table 1 shows the results obtained by five investigators who used somewhat different personal conventions but conforming, in general, to Method *A* (investigators A, D and E) or Method *B* (investigators B and C). In the twenty-eight repetitions the extreme discrepancies were +4.5 per cent and −6.4 per cent, with a mean of ±1.61 per cent.

TABLE I

Investigator						
A	101.1	93.6	98.0	99.6	102.3	100.9
B	100.7	101.9	99.6	99.5	98.6	99.2
C	98.6	99.8	97.3	104.4	101.3	100.2
D	100.5	104.5	100.9	97.1	101.7	
E	99.3	96.9	99.7	100.8	100.8	

Results of repetitions of drawings of diastolic heart outlines made on roentgen kymograms. Each of 5 different investigators made drawings in duplicate of a set of 5 or 6 films. In each case the area of the first drawing by each investigator was taken as 100 per cent and the area of the second drawing was then expressed as a percentage of the first drawing. The table gives these percentage values for the second drawings.

In addition to the series given in Table 1, one of these investigators repeated, after a lapse of several months, the drawings on eighty-two films. With the exception of one repetition which showed a discrepancy of 8.3 per cent, the greatest discrepancies were +4.9 and −5.2 per cent, with a mean discrepancy of only ±1.19 per cent. Finally, two other investigators made independent duplicate drawings on three and four films respectively and obtained mean discrepancies of ±2.2 and ± 1.8 per cent. The grand average discrepancy between 117 pairs of duplicates drawn by seven investigators was ±1.337 per cent. It is clear that the investigator can expect to duplicate his own

results for total area of the posteroanterior projection of the heart.

In a somewhat more critical test the diastolic and systolic heart outlines were drawn by one investigator and then they were independently redrawn from the same films by a second investigator. Drawings on a total of 119 films were repeated in this way, chiefly by three investigators, but a few duplicates were drawn by four other colleagues. Method *A* was used in forty of the films, Method *B* in another forty-five, while the remainder were drawn by mixed techniques which were being tried at the time. The results are given in Figure 6 which summarizes the discrepancies, as percentages of the means, between the duplicates. The average discrepancy between duplicates for this entire series was 2.31 per cent.

Constancy of the Heart Size and Stroke

In order to develop an equation which might permit the calculation of the volume

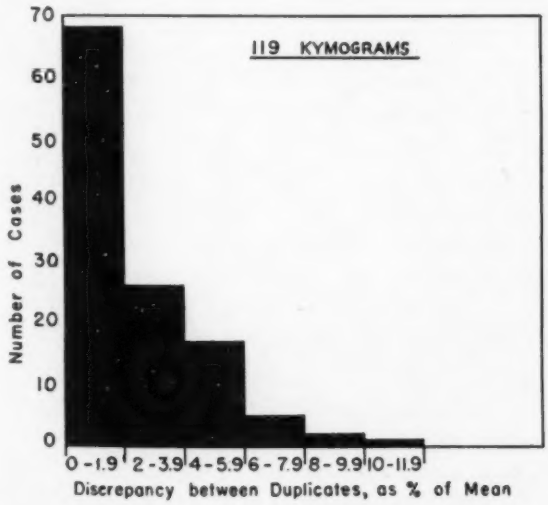


Fig. 6. Repeatability of area measurements on kymograms as shown by comparison of results obtained by independent investigators on the same films.

stroke output of the heart from measurements in systole and in diastole it was necessary to "calibrate" in terms of the acetylene method. But it is not possible to carry out the acetylene rebreathing at precisely the same moment as the kymographic exposure. It was necessary, therefore, to discover whether, under standard conditions, the systolic and diastolic heart sizes are constant over a period of two to five minutes. For this purpose we have analyzed sixty-one such pairs of kymograms taken

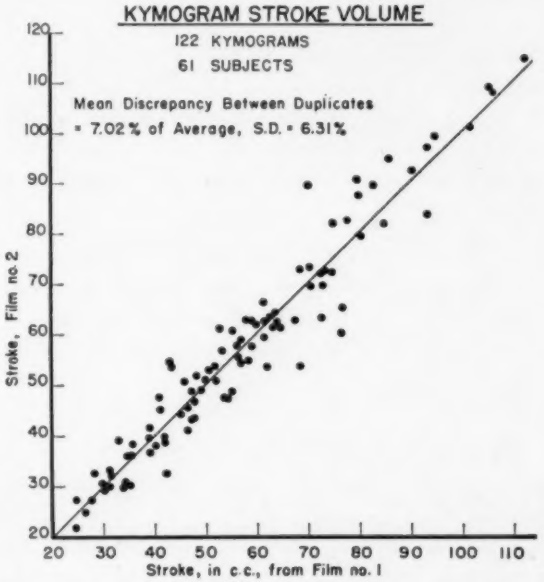


Fig. 7. Constancy of the diastole-systole volume difference registered by the kymogram as indicated by comparison of duplicate films made at an interval of two to five minutes.

on subjects in rest but not under basal conditions. The results, expressed as percentage deviations of the duplicates from their mutual averages, are given in Figure 7. For example, if the measured systolic areas of two duplicate kymograms were 95 and 105, their mutual average is 100 and the percentage deviation of the duplicates is ± 5 per cent.

The foregoing results clearly show that a very high degree of reproducibility and constancy can be attained in drawings of the systolic and diastolic outlines from kymograms. It does not necessarily follow that these *reproducible* areas are equally accurate in absolute terms or that the corresponding predicted volumes are as precise as the relation discovered with the cadavers. In the first place, the difference between systole and diastole must be underestimat-

ed owing to the necessary expedient of drawing a common outline for systole and diastole at the base and at the diaphragm. However, the pulse form of the kymographic waves unquestionably facilitates the recognition of the true heart outline at the base and the apex. We fail to find any reason to suggest that the relation between

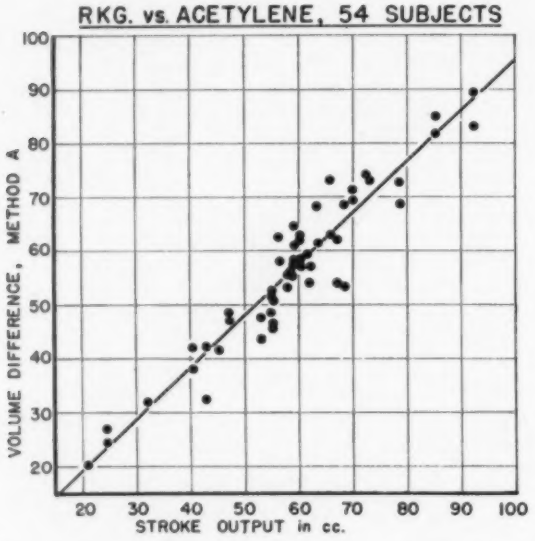


FIG. 8. Results of experiments on 54 subjects with whom simultaneous kymographic exposures and acetylene rebreathing measurements were made. The best straight line was obtained by the method of least squares; its slope is 1.045.

posteroanterior projection area and volume should be sensibly less exact than in the cadavers.

The Measurement of Stroke Output

At the outset it was realized that there may be a relation between the true stroke output of the heart and the change in heart volume from diastole to systole but that it would not be possible to predict the exact form of such a relation from theoretical reasoning. The hypothetical relation should be of the general form:

Stroke output = function of diastolic volume minus systolic volume, or

$$\text{Stroke} = f0.64\ (A_D^{1.45} - A_S^{1.45}).$$

The validity of this equation would be guaranteed if any constant relation could be found between the result of measurement and calculation of the kymogram and the true stroke output measured simultaneously by the acetylene method.

This procedure was carried out in experiments at rest on 54 subjects with normal hearts. The heart outlines were drawn by Method *A* and the apparent volume change from diastole to systole was plotted against the acetylene stroke output as shown in Figure 8. Men, women and children were included in this series and the stroke outputs (acetylene) ranged from 20 to 93 cc. The heart outlines were all drawn by two investigators.

It is obvious that a satisfactory relation does exist between stroke output and the apparent diastolic-systolic volume change and this relation is linear in form. The coefficient of correlation is +0.951. The slope of the straight line of best fit to the observed points (the regression line) is 1.045 and the sought for relation is:

$$\text{Stroke} = 1.045 \times 0.64\ (A_D^{1.45} - A_S^{1.45}), \text{ or}$$
$$\text{Stroke} = 0.67\ (A_D^{1.45} - A_S^{1.45}).$$

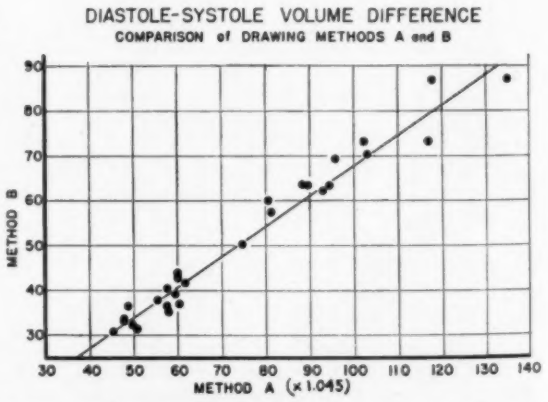


FIG. 9. Comparison of volume difference by Method *B* with stroke output by Method *A*. The regression line (obtained by the method of least squares) is drawn on the graph. Its equation is: stroke volume (Method *A*) = 0.289 + 1.453 × ΔV (Method *B*).

The relation obtained in this way only applies to drawing Method *A* as used by us and a different numerical constant would be required with another drawing method such as Method *B*. It would be necessary, first, to demonstrate that there is a con-

stant relation between results obtained by the two different drawing methods and then to discover this relation. In Figure 9 are given the stroke outputs calculated from Method *A* and the apparent diastolic-systolic volume differences obtained by Method *B* from kymograms on 28 subjects. It is obvious that there is a close linear correlation between the results with the two methods.

The straight line of best fit for the data in Figure 9 was obtained by the method of least squares and this line is drawn on the graph. The equation for this line is:

Stroke volume (Method *A*) = 0.289 + 1.453ΔV (Method *B*). But the constant 0.289 is negligible (less than 2 per cent of the smallest stroke, 20 cc., which we have ever measured), and the best practical equation for Method *B* is:

Stroke = 1.45ΔV (Method *B*).

Table II

Subject	Sex	Surf. m^2	Heart Vol., cc.		ΔV	Δx 1.44	Acet. Stroke	Acet. $1.44\Delta V$
			Diast.	Syst.				
YC SF	f	1.68	495.8	455.5	40.3	58.0	55.2	0.95
LR 15A1	m	1.66	503.6	463.9	39.5	56.9	55.4	0.97
LR 15A2	m	1.66	509.5	468.9	40.6	58.5	55.4	0.95
LR 15A3	m	1.66	537.4	497.9	39.5	56.9	53.1	0.93
LR 15A4	m	1.66	509.8	470.9	38.9	56.0	53.1	0.95
DW 13A1	m	1.80	511.2	470.9	40.3	58.0	58.4	1.01
OH 24A3	m	1.82	581.3	538.9	42.4	61.1	56.7	0.93
ZM 21A3	m	1.69	520.2	455.5	64.7	93.2	92.9	1.00
ZM 21A4	m	1.69	536.6	476.9	59.7	86.0	92.9	1.08
R 22A2	m	1.65	504.5	471.4	33.1	47.7	47.7	1.00
AK 1 SF	m	1.85	674.1	634.8	39.3	56.6	59.0	1.04
AK 2 SF	m	1.85	682.6	642.1	40.5	58.3	59.0	1.01
NG SF	f	1.55	542.6	492.2	50.4	72.6	74.6	1.03
JH SF	m	1.90	566.8	525.0	41.8	60.2	61.7	1.02
AS SF	f	1.54	393.6	350.8	42.8	61.6	60.0	0.97
BK SF	m	1.58	477.3	439.5	37.8	54.4	55.4	1.02
GG 1 SF	m	1.96	782.0	714.2	67.8	97.6	95.0	0.97
GG 2 SF	m	1.96	798.2	735.4	62.8	90.4	95.0	1.05
HK 1 SF	m	1.88	439.8	397.6	42.2	60.8	59.3	0.98
HK 2 SF	m	1.88	422.3	382.5	39.8	57.3	59.3	1.03
EB SF	f	1.71	446.3	390.8	55.5	79.9	74.4	0.93
GM 1 MC	f	1.73	449.8	417.3	32.5	46.8	49.8	1.06
EW SF	m	2.04	447.0	409.8	37.2	53.6	57.9	1.08
AR SF	m	1.78	692.2	632.0	60.2	86.7	86.6	1.00
JR SF	f	1.69	357.2	324.7	32.5	46.8	42.9	0.92
Means					44.9	64.6	64.4	0.995

$$\frac{\text{Acet. Stroke}}{\Delta V} = 1.436,\ \sigma = \pm 0.0689.$$

Comparison of stroke output as measured by the acetylene method and as calculated from the kymogram by Method *B*. Twenty-five experiments on 13 men and 6 women.

If individual points are considered, the most extreme range for the relation between the two methods is given by the ratios 1.34 and 1.65.

The direct test of Method *B* against the simultaneous acetylene measurement was also made. The results of 25 of these experi-

ments are summarized in Table II. The best numerical constant for use in prediction of acetylene stroke output from the kymogram with drawing by Method *B* is obtained from the ratio of the acetylene stroke output to the diastolic-systolic volume difference in this series. Here this value averaged 1.436, $\sigma = \pm 4.69$ per cent, as compared with the constant 1.453 obtained by the indirect test made by comparing Methods *A* and *B* (Fig. 9).

These results of direct and indirect comparison of Methods *A* and *B* are in reasonably close agreement and it is clear that either method is capable of yielding satisfactory estimates of the stroke output. In the light of our extensive trials, however, it must be expected that an inexperienced person might find it difficult to obtain correct *absolute* stroke volumes by following the recommendations and using our numerical factors for either Method *A* or *B*. Personal criteria independently selected for the placement of the systolic outline conceivably might require an average factor, for Method *B*, of anything from 1.2 to 1.7 though it is probable that the extremes would not be more different than 1.3 to 1.6.

TABLE III

Film	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Method A			Method L.H.G.			(3)/(6)
	V_D	V_S	V	V_D	V_S	V	
12A2	723.9	644.0	79.9	724.7	657.5	67.2	1.19
22A1	419.8	384.0	35.8	428.4	400.3	28.1	1.27
55K1	613.7	532.9	80.8	606.8	538.9	67.9	1.19
55K2	614.9	535.2	79.7	610.8	550.7	60.1	1.33
93K1	498.7	435.3	63.4	496.6	440.5	56.1	1.13
12A1	728.0	634.4	83.6	721.4	644.8	76.6	1.09
42A	461.3	415.4	45.9	419.0	375.6	43.4	1.06
42B	477.5	427.0	50.5	420.5	377.0	43.5	1.16
42C	466.3	419.0	47.3	423.3	377.7	45.6	1.04
76K	1264.2	1147.3	117.9	1200.1	1153.0	107.1	1.10
80K1	524.9	467.8	57.1	516.5	471.4	45.1	1.26
80K2	499.5	444.8	54.7	503.9	461.3	42.6	1.28
3KG1	306.2	278.3	28.9	310.1	283.4	26.7	1.08
3KG2	297.5	270.5	27.0	297.5	274.8	22.7	1.19
GGB	788.3	735.4	52.9	766.4	723.0	43.4	1.22
GGA	782.4	713.9	68.5	737.1	684.0	53.1	1.29
71K1	718.9	652.8	66.1	709.0	656.7	52.3	1.27
71K2	692.0	642.0	50.0	707.4	668.6	38.8	1.29
IME	494.5	445.8	48.7	499.3	456.0	43.3	1.13
IMI	622.6	565.3	57.3	628.9	580.9	48.0	1.19
Way	533.1	488.4	44.7	524.7	484.0	40.7	1.10
Ste	469.7	411.4	58.3	516.3	469.7	46.6	1.25
Low	652.6	591.7	60.9	614.1	557.1	57.0	1.07
Means	593.7	534.0	59.1	581.9	534.2	50.3	1.18

Standard deviation ±0.108

Comparison between calculated volume differences between diastole and systole obtained independently by two investigations, one (A.K.) using Method *A* for tracing the cardiac outlines from the kymogram while the other (L.H.G.) used his best judgment rather than set conventions. All volumes, in cc., calculated from the corrected posteroanterior areas by the equation: Vol. $= 0.64\ A^{1.45}$.

In other words, an independent investigator attempting to apply these methods without the benefit of acetylene controls or personal instruction might get results which would *average* 10 per cent too high or too low.

A special test of this point was carried out in which a series of twenty-three films was traced independently by two investigators, one of whom used Method *A*. The other investigator, a radiologist of much general experience, made his drawings to conform with his judgment of the best approximation to the true systolic and diastolic outlines without reference to the special conventions described here as Methods *A* and *B*. This series included both men, women and children with and without cardiac abnormalities. The results are given in Table III. As might be expected, relatively discordant results were reported in some films, but on the whole the two sets of drawings were reasonably concordant with an average factor of 1.180 expressing a consistent difference. A good agreement on total cardiac volume was notable except in a few cases in which differences of the order of 10 per cent resulted from the inclusion or omission of one frame in the vertical dimension. We considered this to be a most severe test, perhaps unfair to these procedures, and the results were entirely satisfactory.

Johnson's Cardiac Index

In a search for other attempts to estimate the cardiac output by roentgenological methods we have found only one paper which merits detailed consideration here. Johnson (1937) used the kymogram and proposed to calculate the change, in the cardiac cycle, of the volume of the left ventricle on the basis of assumptions as to the form of that chamber and the proportion of the heart it occupies in the posteroanterior view. Briefly, he assumed that the left ventricle may be considered as a cylinder of altitude corresponding to the distance from apex to the pulmonary artery and of diameter amounting to 60 per cent of the total transverse diameter of the heart. It was further assumed that the thrust of the wall of this cylinder is uniform in all lateral directions and therefore can be measured by the thrust of the profile observed in the posteroanterior view. Finally, Johnson assumed that the component of motion of the heart parallel to the slit (which is the measurement he used) represents the true thrust of the ventricular wall. The size of the error made in this way depends on the obliquity of the heart; in left ventricular hypertrophy this error ordinarily would be very large.

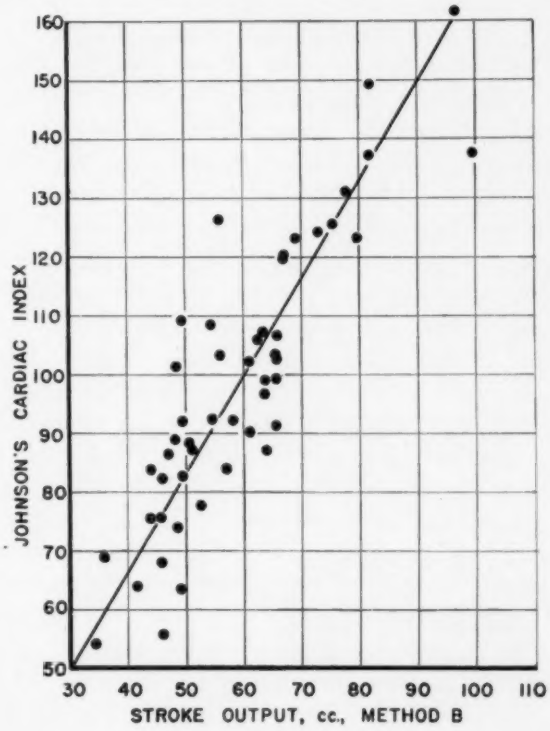


Fig. 10. Comparison of Johnson's cardiac index with the results of our Method *B* applied to 50 kymograms. The slope of the best straight line (drawn on the graph) is 0.603; in other words, on the average, Johnson's index times 0.603 = stroke output in cc.

It is unnecessary to criticize these assumptions; it is important that Johnson applied his calculations to kymograms made while the cardiac output was being estimated by the dye method of Hamilton and others, (1932) and Kinsman and

others (1936) and obtained results which show a significant relation. It is unfortunate that the dye method was chosen since this procedure is not generally accepted by physiologists. Further, though the series is small, the values for normals are decidedly outside the accepted range for normal stroke outputs.

We tested Johnson's method in 50 cases in which the outlines had been drawn from the kymograms by our Method *B*. In order to eliminate one major possible source of discrepancy the measurements for Johnson's method were made directly on our Method *B* tracings and were accurately corrected for triangular distortion. The stroke outputs calculated by the equation, Stroke $= 1.45 \times \Delta V$, were plotted against the corresponding values for Johnson's index in the graph reproduced as Figure 10. There is a marked linear correlation between the two but Johnson's index averages 1.657 times the stroke output. Parenthetically, it may be noted that a number of these films had been made during acetylene rebreathing experiments and afforded proof of the validity of our stroke volume calculations in this series.

Johnson's index may, on the average, be converted into stroke volume by multiplication with the factor 0.603. The standard deviation of this factor was $\sigma = \pm 0.075$ in these 50 films. The relative utility of this method of calculation may be gauged by comparison with the area methods, using the standard deviations as measures of variability. For Johnson's index the standard deviation represents ± 12.45 per cent of the factor necessary to convert to stroke volume without allowance for further error in drawing the heart outlines or for the imperfect nature of the relation between the change of the frontal plane projection of the heart and the volume of the systolic discharge. The factor between our Methods *A* and *B* (Fig. 9) varies within a standard deviation of ± 6.12 per cent. The variation between results for the two procedures tabulated in Table III is, in the same terms, ± 9.15 per cent. In both these latter cases errors in drawing the outlines are included. The data in Figure 8 and in Table II may also be considered though *all* sources of error are included in these direct checks between kymographic calculation and the acetylene procedure. The variation between Method *A* and acetylene stroke volume (Fig. 8) is expressed in the standard deviation of the factor 1.045, $\sigma = \pm 0.091$, or ± 8.70 per cent. Similarly, the series given in Table II which represents the most carefully controlled series we have been able to make, shows a standard deviation of ± 0.069 around the factor 1.44, or ± 4.79 per cent.

When Johnson's index is applied directly in comparison with the stroke output measured by the acetylene method the average discrepancy agrees closely with that indicated in Figure 10; it must be multiplied by a factor of about 0.6 to make the average agree reasonably. As would be expected, the standard deviation of this factor is greater than when the comparison is made simply between the area method calculation from the same drawings. The standard deviation for this direct test (14 cases) represented ± 17.4 per cent of the acetylene stroke output.

It is clear that Johnson's index, suitably corrected, may be used to estimate the stroke output but it is inferior to any of the methods based on area measurements. This is hardly surprising in view of the assumptions and the omission of consideration of the right side of the heart so that pendulum movements are not eliminated.

Relative Changes in Stroke Output

We have emphasized that the stroke output of the heart may be estimated in a variety of ways from the kymogram, but that it is not so easy to be sure of the factor necessary to give the results in correct absolute units. Our evidence indicates that if either Method *A* or *B* is followed rigidly in drawing the outlines the factors given in this paper will yield acceptably correct results in absolute units after a little practice. In many cases, however, it is desired only

to know what are the changes in the stroke output in experimental procedures or in the course of therapy.

It would be expected that such relative changes could be estimated with less attention to a particular technique of drawing the heart outlines. A series of experiments was devised to test this. Simultaneous kymographic and acetylene rebreathing procedures were carried out on young men before and after injecting drugs such as epinephrine and neosynephrin which increase the stroke output but affect the total diastolic size in opposite directions (Keys and Violante, 1940). Pulse rates and metabolic rate were measured almost continuously to ensure accurate estimates of the stroke output by the acetylene method. The heart outlines were drawn by a variety of simple methods, the only consistent feature being that for each experiment the same method was used on all the films for that experiment and that all the procedures tended to minimize the apparent diastolic-systolic difference. The results of nine such experiments are given in Table IV.

Table IV

Subject	Date	(1) Δ Volume Before	(2) Δ Volume After	(3) Ratio	(4) Acetylene Stroke Before	(5) Acetylene Stroke After	(6) Ratio	(7) (3)/(6)
Wil	4/22	32.3	45.0	1.39	62.8	89.5	1.43	0.95
Wat	4/24	24.4	36.7	1.50	57.5	87.5	1.52	0.99
Wil	5/2	32.7	48.7	1.48	58.6	98.0	1.67	0.89
Ric	5/6	40.1	39.2	0.98	55.4	53.1	0.96	1.02
Ric	5/13	32.0	42.4	1.32	57.3	72.1	1.26	1.05
Bro	6/3	31.8	29.9	0.94	79.0	70.1	0.89	1.06
Mil	6/10	44.3	45.3	1.03	83.5	89.0	1.07	0.96
Ric	6/12	41.0	53.4	1.30	47.7	65.2	1.37	0.95
Hon	6/14	30 8	40.3	1.31	45.0	56.7	1.26	1.04

Comparison of stroke output as determined by acetylene and volume change of heart from diastole to systole by kymography in experiments producing alteration of heart function by drugs acting on the sympathetic nervous system. Heart outlines were drawn by various methods but the same method was used throughout each experiment.

Column 7 in Table IV shows that the proportional changes in the stroke output are reasonably well predicted by the kymograms, the average discrepancy being only ±4.8 per cent from the theoretically perfect ratio of 1.00. The significance of this test will be realized when it is considered that the ratios of the ratios given in Column 7 are the resultants of the estimations for four independent complex variables, each one of which possesses its own set of sources of error.

The Normal Stroke Output and Minute Volume in Rest

In normal subjects under basal conditions the minute output of the heart is relatively constant when allowance is made for body size. The size correction is best made in terms of total body surface. This corrected value, liters of blood pumped per minute per square meter of body surface has been termed the "cardiac index" (Grollman, 1932). For 50 normal young adults Grollman reported an average cardiac index of 2.21, range 1.90 to 2.49, average deviation from the mean ±0.14. In these subjects the average stroke output per kilogram of body weight was 0.95 cc., range 0.67 to 1.22, average deviation from the mean 0.11.

In general, similar results have been obtained by others (Christensen, 1931; Starr and others, 1934; Gladstone, 1935; Apéria,

1938) though in different normal series the *average* cardiac index varies from 1.9 to 2.4 and the normal range in any one series is considerably wider than reported by Grollman. In the series of 31 healthy persons studied by Starr and others (1934) the average cardiac index was 2.40, $\sigma = \pm 0.55$.

The data of all investigators are in agreement with Grollman's finding that the stroke output of the heart is something like twice as variable as the minute volume when different individuals are compared. In general, a rapid pulse at rest is associated with a small stroke. This principle is clearly seen in the bradycardia of well-trained athletes. In several series of outstanding athletes which we have studied in the Laboratory of Physiological Hygiene we have found the cardiac index in rest to average 10 to 15 per cent higher than in non-athletes in spite of the fact that the pulse rate averaged 15 to 25 per cent lower in the athletes. It is obvious, therefore, that in comparing the total circulatory function of individuals the cardiac index or minute volume should be the measure of choice rather than the stroke output.

Christensen (1937) has pointed out that the "normal" values for the cardiac index reported by Grollman reflect his use of trained subjects under rigidly controlled physiological conditions. For practical applications, however, it would be desirable to have standards referring to subjects and conditions more comparable to those to be met with in such applications. The series of Starr and others (op. cit.), is probably more useful in this way than that of Grollman.

We applied the acetylene method to 37 healthy persons in the resting, post-absorptive state. Each of these persons was given a dummy trial with the rebreathing procedure some time before the experiment, but they were not "trained." The experiments were carried out after the subject had been seated at least fifteen minutes in the rotating chair used for kymography. In this chair the subject is kept quite erect by support but the subjects were comfortable at all times. The room temperature was from 72 to 78° F. and quiet was maintained throughout. In these 37 cases the cardiac index varied from 1.80 to 3.15 with an average of 2.42, $\sigma = \pm 0.356$. In 34 out of the 37 cases, or nearly 90 per cent, the range was from 1.94 to 3.00. These values are approximately 10 per cent higher than the average for our well-trained subjects under the same conditions.

The minute volume can, of course, be obtained from the kymogram by multiplication of the stroke volume by the pulse rate; the latter can be measured directly on the kymogram if the apparatus is supplied with a time marker. We have made such calculations from kymograms taken under the standard conditions described above and have obtained results in a number of series of normal cases almost identical with those found in the acetylene trials. This means that the kymogram alone can be used as a simple means of detecting and measuring gross abnormalities of the total circulation. Two illustrative cases may be cited.

Mrs. L. S. N., Chinese, aged thirty-eight, was admitted to the San Francisco Hospital with a diagnosis of hyperthyroidism. Her height was 63.7 in. and she weighed 118 lb. Her body surface calculated from the tables of DuBois (1936) was 1.55 square meters. In the basal state her kymogram indicated (Method *B*) a diastolic heart volume of 637.5 cc., systole 583.1 cc., stroke output 78.8 cc. Her pulse rate was 120, indicating a minute volume of 9.43 liters and a cardiac index of 6.08. This is 252 per cent of the normal average and 92 per cent above the normal maximum. Her blood pressure at the time was 136/68 mm., and the basal metabolic rate, measured immediately after the kymogram for comparison, was +82 per cent in terms of the Mayo Foundation standards of Boothby and Berkson (1936).

Mrs. N. K., aged fifty-two, white, was admitted to the University of Minnesota Hospital with a diagnosis of myxedema. Her height was 65 in. and she weighed 156 lb., body surface 1.77 square meters. On December 29, 1938, the cardiac volumes by kymographic examination (Method *A*) were: diastole, 654.1 cc., systole, 622.0 cc., stroke output 33.5 cc. Her pulse rate was 96, hence the minute volume was 3.21 liters

and the cardiac index was 1.81. This is 75 per cent of the normal average and about 10 per cent below the normal minimum. The basal metabolic rate was −24 per cent at this time. Therapy with thyroid was instituted and the kymographic study was repeated on January 25, 1939. At this time the diastolic and systolic volumes were (Method *A*) 636.5 and 609.9 cc., stroke 27.8 cc. Her pulse rate was 120, hence the minute volume was 3.34. The cardiac index at this time, 1.95, was 80.5 per cent of the normal average. The improvement in the circulation had not kept pace with the basal metabolic rate which was now +1 per cent.

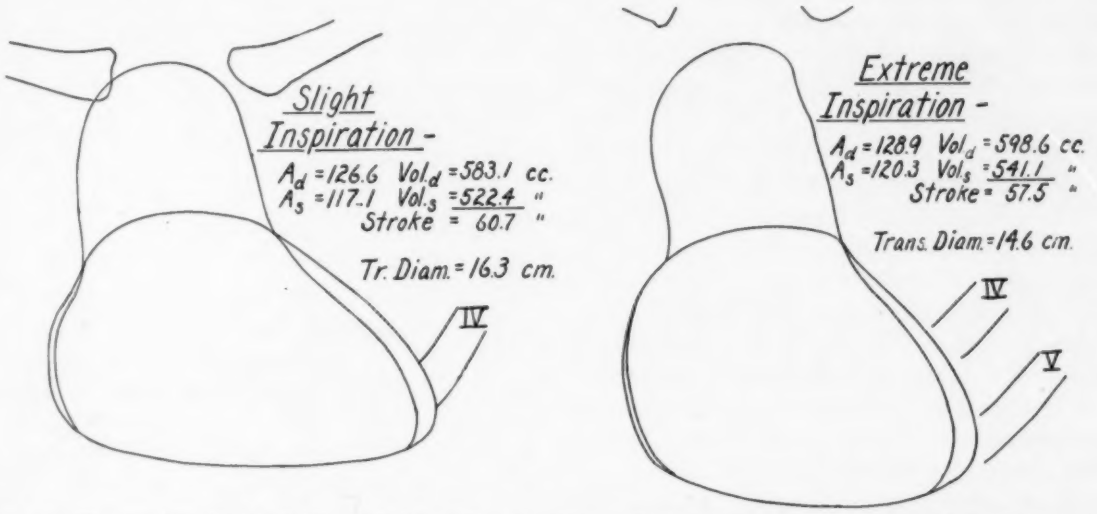


Fig. 11. Illustrating the small effect of phase of respiration on the kymogram when the intrathoracic pressure is not altered greatly. The two kymograms were made on the same subject within three minutes.

The Effect of the Respiratory Phase

It is well known that the position of the diaphragm has a marked effect on the transverse diameter of the heart. The kymogram also reveals effects on the character of the pulsations (Heckmann, 1937; Schlomka and Broich, 1937; Böhme, 1937, 1938). After careful trials we have selected moderate inspiration as the standard condition for kymographic estimation of cardiac function because the best visualization, without danger of alteration of the stroke output, is attained. However, it is remarkable that in most people a considerable latitude in the respiratory phase has relatively small effect on the heart volume and stroke as calculated by the present methods. We have obtained many results in which the posteroanterior areas and calculated strokes were fairly constant all the way from slight expiration to deep inspiration. An example is given in Figure 11 which reproduces drawings made from kymograms and superimposed still teleroentgenograms taken in slight and in extreme inspiration on a well-trained subject under constant conditions during the period of the exposures. These studies will be reported elsewhere; here it is enough to say that it is unnecessary to maintain extremely constant respiratory conditions.

It is essential to guard against abnormally high or low intrathoracic pressures. A powerful inspiratory effort with the internal nares closed can produce a sudden dilatation of the heart and augmented output owing to an excessive venous inflow (Müller phenomenon) which is most marked if the lung inflation is at the expiration level. The Valsalva phenomenon—sudden diminution of heart size and subsequent reduction in stroke output—is produced when an expiratory effort is made with the glottis closed and this occurs more readily than the Müller phenomenon (Natvig, 1934). DuBois-Reymond (1924) recorded intrathorac-

ic pressures as high as 150 mm. Hg in such experiments—around four times the pressure required to overcome the ordinary pressure in the pulmonary artery. When an intrathoracic pressure of 40 to 70 mm. Hg is established the heart volume reduces almost at once and a minimum is attained in three to five seconds (Nolte, 1934; Moberg, 1940). Even as small a positive pressure as 10 mm. Hg may cause a reduction in heart size according to Nolte (op. cit.), but Nordenfelt (1937) stated that an intrapulmonary pressure of about 15 mm. is normal when the respiratory muscles are relaxed and the external passages are closed after inspiration.

In deliberate attempts to produce the Valsalva effect we have recorded kymograms similar to Moberg, showing a great reduction of heart volume (transverse diameter reduction as much as 3.5 cm.) and a diminution of stroke output to as little as a third of normal. For present considerations, however, it is more important that moderate degrees of the Valsalva phenomenon may result accidentally and unconsciously. These can be avoided if the patient is warned not to "set" the chest and not to "strain" against the kymograph. If the patient at first disregards these instructions the fact is apparent to the operator if he watches the back and neck of the patient during the exposure.

ΔV and Stroke Volume

We have endeavored to show that the volume of the heart can be calculated with reasonable accuracy from the area of the posteroanterior projection and that the stroke output of the heart is related to the apparent change of volume in the cardiac cycle by a numerical factor which varies from about 1.0 to about 1.5 according to the method of drawing the diastolic-systolic outlines. Now if the heart were a simple balloon provided with inlet and outlet valves, the change in volume in a "contraction" would be exactly equal to the "stroke output." But if the volume change were estimated from our roentgen kymogram it would be underestimated for the reason that the kymograph registers movements only at right angles to the motion of the film or parallel to the slits, that is, in only one of the two directions of the plane of exposure. In the case of the balloon cited, if the "systolic" radius is x and the true "diastolic" radius is y, the balloon in "diastole" will have an apparent projection shape in the kymogram of an ellipse with semi-axes x and y.* The *true* change in volume would be: $\Delta V_0 = 4/3\pi y^3 - 4/3\pi x^3$, but the apparent (kymographic) change in volume would be: $\Delta V' = 4/3\pi xy^2 - 4/3x^3$. The relation between the true ΔV and the kymographic ΔV is:

$$\frac{\Delta V_0}{\Delta V'} = \frac{y^3 - x^3}{xy^2 - x^3}.$$

The numerical value of this ratio is not constant but varies for different values of x and y; for all possible values of x and y in a balloon approximating to a human heart this ratio is fairly constant at about 1.7. Similar calculations for other geometrical forms lead to the conclusion that, within the limits of sizes and stroke outputs of human hearts, the roentgen kymogram must underestimate the volume change from diastole to systole so that the kymographic volume change is not much more than half the true total volume change.

In the heart the stroke volume refers to the output of a single ventricle, either left or right, and this is what is measured by the acetylene method. The stroke output then is just half the total volume of blood ejected from the ventricles and, returning to something like the simple balloon, the apparent (kymographic) diminution in volume would be about equal to this cardiac stroke volume and numerical factor would be about 1.0.

In the actual heart there are two more important elements which determine the magnitude of the numerical factor. In the

* Note that neither of our methods of tracing the heart outlines attempts to record any motion parallel to the slits at the apex and the base of the heart.

first place the form and position of the heart in the chest are such that the apparent components of contraction are not equal in the upright position in the vertical and horizontal directions, the latter being larger. This fact emerges not only from anatomical considerations but is readily shown by comparing the kymograms taken with vertical and with horizontal film motion, that is with the slits horizontal and vertical respectively. We routinely use the slits horizontal and accordingly we might expect it to be necessary to use a smaller numerical factor than otherwise, something less than 1.0.

The second element is the rôle of atrial filling during ventricular systole. It is difficult to estimate this with certainty. From the relative durations of atrial systole and diastole and the pressures in the atria during the cycle (Wiggers, 1923) it is suggested that something like 20 to 30 per cent of atrial filling takes place during ventricular systole. This would mean that the total change in the volume of the whole heart during the cardiac cycle would be less than the total ventricular output by this amount and the numerical factor would have to be increased accordingly.

Attempts have been made to estimate the net change in heart volume by the "cardiopneumograph" which records the air pressure pulses in the upper respiratory passages in respiratory pause during the cardiac cycle. Conclusions from such studies by Klewitz and Baumm (1921) and Hamilton (1930) that in ventricular systole the excess of outflow over the inflow of blood is very small depend on the assumption that the thorax is a rigid box of fixed volume under these conditions. This has been disproved by thoracic plethysmography by Blair and Wedd (1939) and by kymographic studies of the diaphragm and chest wall in respiratory pause by one of us (Keys, 1940). These two independent methods agree in indicating that atrial filling amounts to a considerable but not a major part of the amount of the systolic discharge and it appears certain that not less than 20 per cent and not more than 40 per cent of the atrial filling takes place during the ejection of blood from the ventricles.

It should be obvious that it is impossible to predict the exact numerical factor to be expected in the relation between ΔV and the stroke output. It seems equally obvious that theoretical and physiological reasoning would indicate as most probable a numerical factor similar to that obtained by the empirical procedure of comparing acetylene stroke outputs with the kymographic change of apparent volume.

Kymographic "Indices" of Cardiac Function

We have already discussed Johnson's cardiac index. Space does not permit similar detailed consideration of other attempts to obtain a numerical expression of cardiac function from the kymogram. The "contraction coefficient" of Iwasaki and Shiga (1938) and the index of de Abreu (1939) are interesting examples of such attempts. The absence of physiologically controlled experiments in both of these studies, however, makes it difficult to evaluate them.

There is every reason to believe that all these investigators—Johnson, Iwasaki and Shiga, and de Abreu—are right in their contention that their respective indices and coefficients should yield valuable estimates as to the functional activity of the heart. The pontifical criticisms of Stumpf (1939) of such attempts appear to spring from physiological misconceptions and a desire to demonstrate that all valuable innovations in kymography were anticipated by the modern father of the subject. Stumpf voices the remarkable belief that the movements of the septum intermedium are more important in emptying the heart than the movements of the muscular walls of the ventricles. It is even more curious that Stumpf apparently still does not appreciate the fact that it is easy to differentiate between movements of the heart as a whole and true contraction by considering both sides of the heart. We quote (op. cit., p. 248):

Der Herzschatten im Kymogramm wird grösser bei jeder Lateralbewegung und kleiner bei

jeder Medialbewegung; diese aber können, wie oben bereits ausgeführt, verschiedene Ursachen haben. Wenn die Vergrösserung und und Verkleinerung der Schattenfläche im Verlauf der Bewegung allein abhängig wäre von vermehrter oder verminderter Füllung der Herzkammern, so würden die Zahlenwerte eine eindeutige Funktion erfassen. Das aber ist nicht der Fall, und alle Schlüsse sind unsicher. . . . Insbesondere müssen wir bedenken, dass wir im Schattenbild nur die Aussenbewegungen der Herzwand erfassen, dass aber Füllung und Entleerung vor allem durch die Innenbewegungen des Septums zwischen Vorhof und Kammer geregelt wird.

We have already discussed these points. It might be pertinent to add, however, two obvious points. In the first place the heart muscle and the contents of the chambers are incompressible. Secondly, Stumpf's argument would indicate that the musculature of the interventricular septum does most of the pumping work and the vastly greater bulk of the musculature of the ventricular walls is largely passive!

Valvular Pathology

Stenosis of any of the heart valves alters the shape of the contraction wave recorded by the kymogram and this fact may be of diagnostic value (Stumpf, Weber and Weltz, 1936), but it does not necessarily interfere seriously with the estimation of the output of the heart by the present method. If the stenosis is very severe there may be an alteration of the relative amount of atrial filling which takes place during ventricular systole and this could disturb the numerical calculations. For example, in high grade aortic stenosis the ventricular discharge may be relatively prolonged so that more of the atrial filling takes place at this time and the change in volume of the whole heart during the cycle will be less than the ordinary proportion of the stroke output. Such evidence as we have so far indicates that the error from this source cannot be large.

Regurgitation through the valves will have the opposite effect and in this case the discrepancy can be very important (Keys and Friedell, 1939). The situation is particularly clear in aortic regurgitation where a considerable portion of the blood expelled by the left ventricle in systole returns in diastole. We have made a large series of studies in such cases which will be presented elsewhere but several points may be mentioned here.

The acetylene method measures the net circulation of blood and any part of the systolic discharge which returns to the heart in diastole does not appear in the measurements. On the other hand, the kymogram only records the difference in the size of the heart in diastole and systole without regard to the destination of the blood expelled in systole or the source of the blood taken in during diastole. We should expect, therefore, that the kymographic output would exceed the acetylene output in cases of aortic regurgitation and that the difference should represent, roughly at least, the amount of regurgitation. This is exactly what we have found. In severe aortic regurgitation the kymographic output may be double the acetylene output and even in cases where the clinical diagnosis is "slight aortic regurgitation" there is a difference of 10 to 25 per cent. In uncomplicated cases the apparent "leak"—difference between kymographic and acetylene outputs—is roughly proportional to the pulse pressure as we might expect.

Abnormally large pulsations of the heart are well known to be characteristic of aortic regurgitation. The net circulation is now, however, large and we have found that the cardiac index determined in these cases by the acetylene method is about normal. Accordingly it seems to be possible to make a rough estimate of the degree of regurgitation from the kymogram alone.

Patent Ductus Arteriosus

Similar relations are found in cases of persistence of the ductus arteriosus. In collaboration with Dr. M. J. Shapiro a series of 12 cases of patent ductus arteriosus has been studied by these methods with results that are almost indistinguishable from the

cases of aortic regurgitation. Apparently the flow through the ductus can be very large—up to 50 per cent of the kymographic stroke output—and as in aortic regurgitation the "leak" is roughly proportional to the arterial pulse pressure. In one patient the diagnosis was verified at postmortem examination which revealed an anatomical situation entirely compatible with the kymographic and acetylene results. These studies will also be reported in detail in a separate publication.

Discussion

It will have been noted that our approach to the problems considered in this paper has been to start with fundamental anatomical and physiological considerations and then to proceed by controlled experiments to investigate the several relations empirically. The complexity of the anatomy and movements of the heart excludes the possibility of arriving at exact quantitative relationships by theoretical analysis but we have been concerned to show that the empirical results are in reasonable agreement with theoretical expectations. This attempt seems to be successful but if apparent discrepancies had appeared it would have merely indicated that there is a fault in the theory. In other words, the empirical relationship is the existent fact and no amount of theoretical argument can change this.

In the course of these studies we sought to improve our understanding as to why the empirical relations exist by numerous studies with the heart in lateral and oblique positions and with registration of the movements in various planes. It is unnecessary to devote the large amount of space needed to expound these results. They simply show that the posteroanterior view is by far the most suitable for the present purposes and that there is little gained by adding data from other views except in rare cases. Moreover, the studies with the other views reinforce our belief that the numerical factors reported here are reasonable and that our ideas as to the mechanics of the heart movements are correct.

Others may judge as to the practical utility of the methods used here. We believe that the limitation of roentgenological study to problems mainly conceived in morphological terms is gradually disappearing and that the rich field of function is bound to be developed more and more.

Table V

"c," in cm.	Correction Factors for Film-Target Distances		
	60 in.	66 in.	72 in.
5.0	0.9355	0.9412	0.9460
6.0	0.9228	0.9297	0.9356
7.0	0.9103	0.9182	0.9250
8.0	0.8978	0.9068	0.9145
9.0	0.8854	0.8955	0.9040
10.0	0.8731	0.8843	0.8936
11.0	0.8609	0.8731	0.8834
12.0	0.8488	0.8619	0.8731
13.0	0.8366	0.8509	0.8629
14.0	0.8247	0.8399	0.8528
15.0	0.8129	0.8290	0.8427

Factors with which to multiply the measured posteroanterior projection heart area to correct for triangular distortion when the film-to-target distance is 60, 66, or 72 inches (152.4, 167.6, or 182.9 cm., respectively). The "c" values here represent the total distance from the mid-point of the heart to the film in the posteroanterior position. This is satisfactorily estimated from a lateral film or as one-third the external posteroanterior diameter of the chest, plus the distance from the outside of the sternum to the film. The factor is a linear function of "c" so these tables may be expanded by graphical plot of the values given here.

Visual inspection of a film is, of course, of first importance, but one might wish for much more exact mensuration. In the great majority of roentgenological departments the only measurement made on the heart is that of the transverse diameter or the so-called cardiothoracic ratio. The inadequacy of this measurement for gauging the heart size has been repeatedly demonstrated, notably in the precise studies of Benedetti (1936) and Ludwig (1939) and it has been very evident in our own work. Of all the indices of heart size studied by Ludwig, the transverse diameter and the cardiothoracic ratio proved to be the most inaccurate and

the least useful. We may call attention to Figure 11 in this paper by way of illustration.

Planimetric measurement of the area of the posteroanterior projection has been repeatedly shown to be the best single measurement for estimating the true size of the heart (Hodges and Eyster, 1924; Hammer, 1928; Moritz, 1931; Kahlstorf, 1932; Hodges, Adam and Gordon, 1933; Dedic, 1938). But planimetric measurement is no more difficult to make on a kymogram than on an ordinary roentgenogram and the uncertainty of the phase of the cardiac cycle represented is removed. The error involved by neglect of this last point is not insignificant as is apparent from the present studies as well as those of Schlomka and Broich (1937), Ludwig (1938) and others.

It would seem, therefore, that there is every reason for using planimetric measurements of kymograms for routine estimation of heart size. If this is done, however, it is not much more difficult to measure both

TABLE VI

A	Vol.	A	Vol.	A	Vol.	A	Vol.	A	Vol.
50	186.0	80	367.8	110	583.6	140	828.1	170	1097.3
1	191.5	1	374.4	11	591.4	41	836.7	71	1106.7
2	196.9	2	381.2	12	599.2	42	845.3	72	1116.1
3	202.2	3	387.9	13	606.8	43	854.0	73	1125.5
4	208.0	4	394.8	14	614.7	44	862.6	74	1135.0
								75	1144.4
5	213.5	5	401.7	15	622.6	45	871.3		
6	219.3	6	408.6	16	630.5	46	880.1	76	1153.9
7	225.0	7	415.4	17	638.3	47	888.8	77	1163.5
8	230.7	8	422.4	18	646.2	48	897.5	78	1173.0
9	236.5	9	429.7	19	654.2	49	906.4	79	1182.6
60	242.5	90	436.4	120	662.2	150	915.2	180	1192.2
1	248.3	1	443.4	21	670.3	51	924.1	81	1201.8
2	254.3	2	450.5	22	678.3	52	933.0	82	1211.4
3	260.3	3	457.7	23	686.4	53	942.0	83	1221.0
4	266.2	4	464.9	24	694.5	54	950.9	84	1230.8
5	272.2	5	471.9	25	702.6	55	959.9	85	1240.5
6	278.3	6	479.1	26	710.8	56	968.7	86	1250.3
7	284.6	7	486.4	27	718.9	57	977.8	87	1260.1
8	290.9	8	493.7	28	727.2	58	986.9	88	1269.8
9	296.8	9	501.0	29	735.4	59	995.9	89	1279.5
70	303.1	100	508.4	130	743.7	160	1005.0	190	1289.3
1	309.4	1	515.8	31	752.0	61	1014.1	91	1299.4
2	315.7	2	523.4	32	761.3	62	1023.3	92	1309.3
3	322.1	3	530.8	33	768.8	63	1032.4	93	1319.0
4	328.5	4	538.2	34	777.2	64	1041.6	94	1328.9
5	335.0	5	545.7	35	785.8	65	1050.8	95	1338.8
6	341.4	6	553.0	36	794.0	66	1060.1	96	1349.0
7	348.0	7	560.6	37	802.5	67	1069.4	97	1359.0
8	354.6	8	568.4	38	811.0	68	1078.9	98	1369.0
9	361.2	9	576.0	39	819.7	69	1088.0	99	1379.0

Values for heart volume from the corrected frontal plane area according to the equation: Vol. $=0.64\ (A)^{1.45}$. These values here may be used for the construction of graphs for interpolation to 0.1 cm.^{2} Areas (A) in cm.^{2}, volumes in cc.

diastole and systole and thereby obtain a measure of the stroke output as well. To facilitate the calculations we have appended Tables v and vi.

If size only is to be studied there is a question as to whether systole or diastole should be used as the standard. It is easier to agree on the diastolic outline, and ordinary size estimates by other methods generally refer more closely to diastole than to systole. These are powerful arguments for the selection of diastole as the standard but there are other considerations. In the estimation of heart size, the desire is to find the best value for the heart itself and not necessarily the heart plus the contained blood. Systole more nearly approximates this end. Further, changes in the physiological state have much more effect on diastole than on systole, so that it is clear that systole is the more constant condition. The arguments are nicely balanced and final solution must await further studies.

Tables for Calculation

Quantitative estimation of the stroke output of the heart from the kymogram requires correction of the measured areas for distortion, conversion of these corrected areas into volumes, and final multiplication of the volume difference between diastole and systole by the factor appropriate to the drawing method used.

Table v gives area correction factors for 60, 66 and 72 inch film-target distances for heart-film distance in steps of 1 cm.; smaller steps may be obtained by linear interpolation. Table vi gives the heart volumes corresponding to the corrected areas from 50 to 199 square centimeters (186.0 to 1,379.0 cc.). The 1 sq. cm. steps are close enough for simple estimation of heart size but for the estimation of stroke output it is necessary to interpolate. Accurate interpolation values can be obtained by making a large scale graphical plot of the values in Table vi.

SUMMARY

Studies are reported on the use of the multiple slit roentgen kymograph for the estimation of the size (volume) and output of the human heart. More than 700 hired subjects and volunteers were studied, including healthy normals, outstanding athletes, hospital patients with normal hearts, and cases of cardiac disease including hypertension, valvular disease and congenital defects.

Three different kymographic machines were used in four different roentgen departments. Essentially identical results were obtained. A standard film-target distance of 66 inches was used except in a few series in which 60 inches was used. Technical factors are discussed and recommendations to assure good results are given.

Methods used to estimate systolic and diastolic frontal areas of projection are discussed in detail. Data from comparison of kymograms studied by different methods and by different investigators show that consistent results can be obtained but that different conventions—methods of tracing outlines—require different numerical constants.

The movements of the heart as recorded by the kymogram are discussed, particularly with regard to the differentiation of volume changes and changes in shape and position of the heart.

The results are given of comparisons of heart volume estimated from frontal plane projection area and measured directly in 35 cadavers. The volume is related to the corrected area by the equation $V = 0.64\ (A)^{1.45}$, with a mean error of ± 4.5 per cent.

A large number of experiments was performed to disclose the numerical relation between the kymographic change from diastole to systole and the true net stroke output. Simultaneous kymographic and acetylene rebreathing methods were used in 88 subjects with normal hearts and with other subjects with abnormal hearts but with no evidence of insufficiency. A satisfactorily constant relation was found, the exact numerical factor being dependent on the particular methods used to estimate the heart volume. The factors required for the different methods are given and discussed in detail.

Comparison of results with the present methods was made with Johnson's cardiac index in 50 cases. It was found that Johnson's method gives a rough estimate of the true stroke output provided a large numerical correction is made.

Experiments in which the stroke output was altered by drugs are reported. These show that relative changes in stroke output may be estimated with little regard for the precise volume estimation.

The normal stroke output and minute volume in rest is discussed and results of special experiments on 37 subjects are reported. The use of the kymogram alone to estimate total circulatory function is illustrated by hyperthyroid and hypothyroid cases.

The effect of the respiratory phase was studied, and it is shown that the present methods are not greatly affected by the respiratory phase unless the intrathoracic pressure is abnormal. The possibility of errors from the Valsalva and Müller phenomena is pointed out.

The cardiac mechanics involved in the relationship between stroke volume and the volume difference of the whole heart in diastole and in systole is discussed. It is shown that the numerical values found here are in reasonable agreement with physiological and anatomical reasoning.

The special conditions of valvular disease are noted and a means is indicated for estimating the regurgitation in certain types by the present methods. Similar considerations apply to functional persistence of the ductus arteriosus. Results from studies or cases of patent ductus and of aortic regurgitation reinforce the arguments.

Discussion and tables of factors are given to facilitate practical application of the methods described. The problem of routine estimation of heart size is discussed and the use of the roentgen kymogram for this purpose is urged.

REFERENCES

1. DE ABREU, M. Die kymographische Beurteilung der Herztätigkeit. *Fortschr. a. d. Geb. d. Röntgenstrahlung*, 1939, *59*, 91–120.
2. APÉRIA, A. Contribution à l'étude de la physiologie de la circulation en relation avec l'âge. *Acta med. Scandinav.*, 1938, Suppl. 89, pp. 214–223.
3. BARDEEN, C. R. Determination of size of the heart by means of x-rays. *Am. J. Anat.*, 1918, *23*, 423–487.
4. BENEDETTI, P. Die klinische Morphologie des Herzens und ihre Auswertungsmethodik bei Herzgesunden und Herzkranken. *Ergebn. d. inn. Med. u. Kinderh.*, 1936, *51*, 531–622.
5. BENEDETTI, P., and BOLLINI, V. Valutazione metrica e ispettiva del cuore dei cardiopazienti. L. Capelli, Bologna, 1936.
6. BLAIR, H. A., and WEDD, A. M. Measurement in man by pneumocardiographic method of excess of arterial outflow from chest over venous inflow during heart cycle. *Am. Heart J.*, 1939, *17*, 536–541.
7. BÖHME, W. Ueber zwei neue, von der Respiration abhängige, klinisch erfassbare, röntgenologisch geklärte Herzphänomene. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1937, *55*, 107–117.
8. BÖHME, W., and HINRICHSEN, R. Ueber die Veränderungen der Pulsation des Herzens während der Atmung im Zusammenhang mit einer Funktion des Herzbeutels. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1938, *57*, 65–73.
9. BREDNOW, W., and SCHAARE, U. Kymographische Untersuchungen des normalen Herzens. *Ztschr. f. klin. Med.*, 1933, *125*, 480–492.
10. BROEMSER, P., and RANKE, O. F. Ueber die Messung des Schlagvolumens des Herzens auf unblutigem Weg. *Ztschr. f. Biol.*, 1930, *90*, 467–507.
11. CHRISTENSEN, E. H. Gasanalytische Methoden zur Bestimmung des Herzminutenvolumens in Ruhe und während körperlicher Arbeit. *Arbeitsphysiol.*, 1931, *4*, 175.
12. CHRISTENSEN, E. H. Minutenvolumen und Schlagvolumen des Herzens während schwere Körperlicher Arbeit. *Arbeitsphysiol.*, 1931, *4*, 470.
13. CHRISTENSEN, E. H. Das Herzminutenvolumen. *Ergebn. d. Physiol.*, 1937, *39*, 348–407.
14. CIGNOLINI, P. Die Röntgenkymographie mit unterbrochenem Schlitz. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *49*, 224–240.
15. CIGNOLINI, R. Roentgenchimografia. *Radiol. med.*, 1935, *22*, 791–794.
16. DEDIC, S. Die Ermittlung der proportionalen Herzgrösse. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1938, *57*, 153–167.
17. DUBOIS-REYMOND, R. Mechanik und Innervation der Atmung. Lehrbuch d. Physiol. d. Menschen von W. Trendelenburg and A. Loewi, Leipzig, 1924, p. 229.
18. FRANKLIN, K. J. Rotatory movements of apex of exposed mammalian heart. *J. Physiol.*, 1939, *96*, 164–167.

19. Gladstone, S. A. Cardiac Output and Arterial Hypertension. The Author, New York City, 1935.
20. Gladstone, S. A. Cardiac output and related functions under basal and postprandial conditions. *Arch. Int. Med.*, 1935, *55*, 533–546.
21. Groedel, F. M. Die Röntgendiagnostik der Herz- und Gefässerkrankungen. H. Muesser, Berlin, 1912.
22. Grollman, A. The Cardiac Output of Man in Health and Disease. Charles C Thomas, Springfield, Ill., 1932.
23. Grollman, A., Friedman, B., Clark, G., and Harrison, T. R. Studies in congestive heart failure. XXIV. Critical study of methods for determining cardiac output in patients with cardiac disease. *J. Clin. Investigation*, 1933, *12*, 751–766.
24. Hamilton, W. F. Filling of normal human heart in relation to cardio-pneumogram and abdominal plethysmogram. *Am. J. Physiol.*, 1930, *91*, 712–719.
25. Hamilton, W. F., Moore, J. W., Kinsman, J. M., and Spurling, R. G. Studies on circulation; further analysis of injection method, and of changes in hemodynamics under physiological and pathological conditions. *Am. J. Physiol.*, 1932, *99*, 534–551.
26. Hammer, G. Die Herzfläche als Massstab für die Herzgrössenbestimmung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 1000–1015.
27. Heckmann, K. Die Lageänderungen des Herzens während der Pulsation und ihr Ausdruck im Flächenkymogramm. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1937, *55*, 319–333.
28. Henderson, Y. Mass movements of circulation as shown by a recoil curve. *Am. J. Physiol.*, 1905, *14*, 287.
29. Hodges, P. C., and Eyster, J. A. E. Estimation of cardiac area in man. Am. J. Roentgenol. & Rad. Therapy, 1924, *12*, 252–265.
30. Hodges, P. C., Adam, W., and Gordon, W. Estimation of cardiac area in children. *J. Am. M. Ass.*, 1933, *101*, 914–916.
31. Iwasaki, H., and Shiga, T. Röntgenkymographische Untersuchung der Herztätigkeit. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1938, *58*, 484–507.
32. Johnson, S. E. Roentgen kymography considered in relation to heart output, and a new heart index. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 167–174.
33. Kahlstorf, A. Ueber eine orthodiagraphische Herzvolumenbestimmung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1932, *45*, 123–146.
34. Keys, A. Movements of human diaphragm during cardiac cycle in respiratory pause. *Proc. Soc. Exper. Biol. & Med.*, 1940, *44*, 1–4.
35. Keys, A., and Friedell, H. L. Measurement of stroke volume of human heart from roentgenograms; simultaneous roentgenkymographic and acetylene-rebreathing experiments. *Am. J. Physiol.*, 1939, *126*, 741–752.
36. Keys, A., and Friedell, H. L. Measurement of heart size with roentgenkymograph. *Proc. Soc. Exper. Biol. & Med.*, 1939, *40*, 267–270.
37. Keys, A., and Friedell, H. L. Quantitative measurement of valvular efficiency of human heart. *Proc. Soc. Exper. Biol. & Med.*, 1939, *40*, 556–559.
38. Keys, A., and Violante, A. Size and stroke of normal human heart during neosynephrin bradycardia. *Proc. Soc. Exper. Biol. & Med.*, 1940, *44*, 462–464.
39. Kinsman, J. M., Moore, J. W., Hamilton, W. F., and Spurling, R. G. Dye-injection method of studying circulation. Christian Birthday Volume. Waverly Press, 1936, pp. 33–50.
40. Klewitz, F., and Baumm, F. Ueber die durch die Herzaktion bedingten intrathorakalen Druckswankungen und ihre praktische Verwertung. *Deutsches Arch. f. klin. Med.*, 1921, *135*, 108–114.
41. Lequime, J. Le débit cardiaque; études expérimentales et clinique. Masson et Cie, Paris, 1940.
42. Lorens, J. Nouvelle méthode rotatoire de radiokymographie du coeur. *J. de radiol. et d'électrol.*, 1937, *21*, 294–297.
43. Ludwig, H. Röntgenaufnahmen des Herzens während bestimmter Aktionphasen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1938, *57*, 515–523.
44. Ludwig, H. Röntgenologische Beurteilung der Herzgrösse. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1939, *59*, 1–52.
45. McGuire, J., Hauenstein, V., and Shore, R. Cardiac output in heart disease determined by direct Fick method, including comparative determinations by acetylene method. *Arch. Int. Med.*, 1937, *60*, 1034–1042.
46. Moberg, G. Some views on important part played by pressure conditions in chest and abdomen for radiographic examination of heart and lung. *Acta radiol.*, 1940, *21*, 1–20.
47. Moritz, F. Ueber die Norm der Grösse und Form des Herzen beim Mann. *Deutsches Arch. f. klin. Med.*, 1931, *171*, 431–476.
48. Natvig, P. Volume of the heart in Müller's and Valsalva's tests. *Acta radiol.*, 1934, *15*, 657.
49. Nolte, F. A. Ueber die Veränderung der Herzform und -grösse unter der Entwirkung intrapulmonaler Drucksteigerung nach kardiokymographischen Untersuchungen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *50*, 211–230.
50. Nordenfelt, O. Die Elastizität der Lungen und Valsalvasche Versuch. *Acta med. Scandinav.*, 1937, *93*, 297–307.

51. SCHLOMKA, G., and BROICH, W. Ueber die physiologischen Schwankungen der Herzgrösse. *Arch. f. Kreislaufforsch.*, 1937, *1*, 384–404.
52. SCHRODERER, K. Ueber die praktische Bedeutung des Fokus-Filmabstandes bei der Herzkymographie. Inaug. Diss., München, 1938.
53. Schwarzschild, M. M. The physical principles of slit kymography. *Radiology*, 1939, *33*, 90–107.
54. STARR, I., JR., DONAL, J. S., MARGOLIES, A., SHAW, R., COLLINS, L. H., and GAMBLE, C. J. Studies of heart and circulation in disease; estimations of basal cardiac output, metabolism, heart size, and blood pressure in 235 subjects. *J. Clin. Investigation*, 1934, *13*, 561–592.
55. STEWART, H. J., DEITRICK, J. E., and CRANE, N. F. Studies of circulation in patients suffering from spontaneous myxedema. *J. Clin. Investigation*, 1938, *17*, 237–248.
56. STUMPF, P. Die Gestaltänderung des schlagenden Herzens im Röntgenbild. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 1055–1067.
57. STUMPF, P., WEBER, H. H., and WELTZ, G. A. Röntgenkymographische Bewegungslehre innerer Organe. Georg Thieme, Leipzig, 1936.
58. STUMPF, P. Bemerkungen zur Kritik der Kymographie des Herzens. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1939, *59*, 242–249.
59. TIGERSTEDT, R. Physiologie des Kreislaufes. Second edition. Walter de Gruyter, Berlin, 1921.
60. UNGERLEIDER, H. E., and GUBNER, R. Teleoroentgen kymography; its application to study of heart size, output, and aortic elasticity. *Radiology*, 1939, *33*, 497–507.
61. WESTERMARK, N. Studien über die Bewegungen des Herzens. *Acta radiol.*, 1936, *17*, 235–250.
62. WIGGERS, C. J. Circulation in Health and Disease. Second edition. Lea & Febiger, Philadelphia, 1923.
63. WIGGERS, C. J. Pressure Pulses in the Cardiovascular System. Longmans, Green & Co., London and New York, 1928.
64. WOLFERTH, C. C., and MARGOLIES, A. Movements of roentgen-opaque deposits in heart valve areas. *Am. J. M. Sc.*, 1939, *197*, 197–201.

DISCUSSION

DR. WENDELL G. SCOTT, St. Louis, Mo. The paper we have just heard is a contribution to the study of cardiodynamics, and especially in valvular heart disease. At the present time the usual methods of roentgenologic diagnosis of heart disease are based upon the anatomic and pathologic changes as interpreted from the size and shape of the cardiac silhouette. We can usually help the clinicians on these points, but today they are seeking the answers to such questions as: What am I going to do with this man? What is his prognosis? Shall I restrict his physical efforts? Is it safe to let him continue his work? In order to help him with these questions, we have to give him some idea of the efficiency of the heart. The essayists' work is one method that may help us to answer these questions.

It is interesting to go back and see the enormous amount of work that this paper represents. These men have worked in both the roentgenological and physiological departments, and they have collaborated their reports to bring us this information.

To summarize, Keys, Friedell and Rigler did a series of postmortem experiments and found that by using a modification of Bardeen's formula and their height-weight chart they could calculate the total heart volume from a measurement of the area of the frontal cardiac silhouette with an average error of less than −5 per cent as checked by postmortem examinations.

As you all know, it is very simple to obtain the outline of the living human heart in both ventricular systole and diastole from a kymogram. The essayists used the kymograms to calculate the surface in systole and diastole, and then, by using their formula, the volume of the heart in systole and diastole is calculated within the same reasonable limits.

The essayists then go on by assuming that the difference between the volume of the heart in systole and diastole is directly related to the stroke output of the heart if the valves do not permit any back flow. It seems reasonable that there is some relationship here, but certain other factors, such as the movement of the interventricular septum, influence the picture.

They make roentgen kymograms immediately before and after acetylene rebreathing experiments. By this means they obtain estimates of diastolic and systolic volumes of the heart from kymograms and the cardiac stroke output by the method of Grollman.

In order to determine whether this relationship could be used clinically they determined the stroke output of the heart by the Grollman acetylene-rebreathing method and compared this figure with that obtained by subtracting the volume of the heart in systole from the volume of the heart in diastole as calculated from the kymograms. They found that these two figures have a close relationship and were of the

same magnitude in each instance. Apparently the possible errors in their assumptions cancelled each other in such a way that it seems that we now have a relatively simple method of obtaining a reasonably accurate value for the stroke output of the heart from a kymogram. The accuracy of this method must be checked by more experience.

Following this work the essayists attempted to measure the efficiency of the cardiac output in patients with valvular disease. They considered the stroke output of the heart as obtained from the kymogram as the total amount of blood expelled from the heart. This value would be also the amount of blood circulated by the stroke in normal hearts but not in hearts with leaky valves. In hearts with valvular disease the amount of blood circulated by the stroke output can be reasonably estimated by the acetylene rebreathing method. Thus the difference in the stroke output measured by the kymogram less the net output obtained by the acetylene rebreathing method would be the amount of blood that regurgitates back into the heart. This value was calculated in percentage.

I think Drs. Keys, Friedell, and Rigler are to be complimented for an excellent study. We should realize that this is a preliminary report and does not show the final results.

Dr. Keys (closing). I should like to say that the nature of the agreement between the acetylene stroke output and the calculated kymogram stroke is to be expected because the acetylene method measures the *net* output, that is, *half* the output of the two ventricles, and the kymograph, as we use it, registers only the changes in size in the horizontal direction. In other words, if the heart were like a simple expanding balloon, the kymogram would register about *half* the actual change in size. In the heart, however, the components of motion in the horizontal direction are somewhat greater than in the vertical direction so we might expect the kymographic size change to be greater, by something like 15 to 30 per cent, than the acetylene stroke. On the other hand, it is known that something like 20 per cent of auricular filling takes place during ventricular systole so the size change of the heart should be reduced by this amount. The net result is that we should expect, *a priori*, that the size change of the heart as registered by the kymogram would be approximately the same as the acetylene stroke output. The fact that the kymogram registers not only contraction but all movements of the periphery of the heart having horizontal components, does not disturb the calculations. At any given moment a simple displacement of one side of the heart is compensated by an opposite displacement of the other side of the heart. In this respect a movement of the septum is precisely the same as a pendulum or rocking motion of the whole heart. If ventricular contraction displaces the septum intermedium then the excursion of the ventricular periphery may be magnified but an opposite excursion equal to the magnification will take place in the atrial periphery. It should be noted, that, in the posteroanterior projection, the visible atrial periphery is about as great in extent as the visible ventricular periphery. This merely emphasizes our contention that it is essential to measure the *areas* of the systolic and diastolic silhouettes. It is a coincidence, of course, that the change in size indicated by the kymogram by our method *A* is almost exactly—within about 5 per cent in the heart with normal valves—the same as the acetylene stroke output.

ROENTGEN APPEARANCE OF THE ENLARGED LEFT AURICLE IN PATIENTS WITH MITRAL DISEASE*

(IN THE FRONTAL POSITION)

By DANIEL ROUTIER *and* R. HEIM DE BALSAC
PARIS, FRANCE

FOR a number of years we have been developing a technique for opacification of the heart cavities and large mediastinal vessels which has enabled us, from the study of nearly one hundred subjects, to locate accurately each cavity in the heart silhouette and show their behavior in the course of different diseases of the heart. It was these anatomical-roentgenological studies on the opacified cadaver that led us to try to determine whether the direct examination of the heart silhouette in the living subject would permit of a good and accurate evaluation of the left auricle in the frontal position.

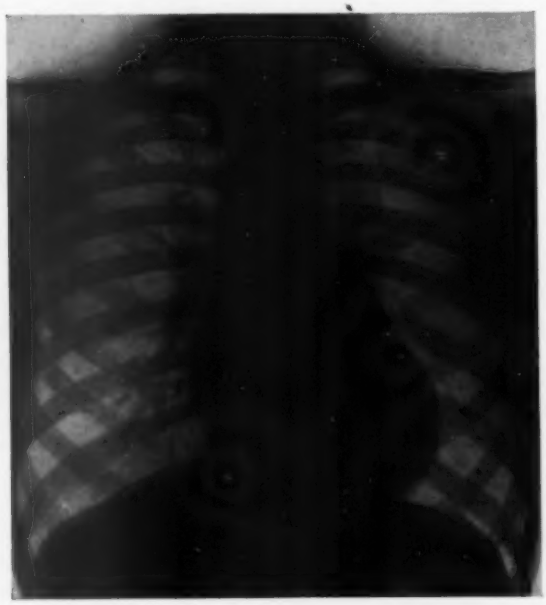


FIG. 1. Male, aged twelve. Rheumatic endocarditis, progressive, with mitral and aortic valvulitis; regular rhythm. The left auricle slightly enlarged has developed backward, and in the frontal projection shows a darker disc in the midst of the heart mass; the right border of this disc with the right border of the heart shows a "double outline" image.

We have on several occasions insisted that the projection of the normal left auricle was enclosed entirely inside the heart shadow and that it did not participate at any point in the formation of any segment of the silhouette. It is in only a few cases that the tip of the auricle projects into the lower part of the middle arch. In fluoroscopy as in the roentgenogram the left auricle in the normal subject is usually invisible in the frontal position; the heart shadow shows a homogeneous density which makes it impossible to distinguish this cavity.

But as soon as the left auricle increases in size its anteroposterior diameter in-

FIG. 2. Female, aged forty-two. Choreic mitral endocarditis beginning at the age of fourteen with complete arrhythmia at present. The left auricle, increased in size, has developed to the right and backward; in the frontal position its projection forms a dark disc which emerges from the heart mass in the right angle between the heart and great vessels; this is a transition form between the double outline and the double festoon images.

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

creases. The left auricle is in fact an essentially posterior cavity and therefore it finds a free field for its development primarily backward. Because of the increase in size of the cavity the mass of blood contained in it increases in thickness and for this reason it contributes to increasing the density of the heart shadow at the place where it is located. This increase of opacity is distinctly circumscribed in the sector of the silhouette in which our selective cadaver opacifications have shown definitely that the left auricle is located, that is to say, the right upper sector and even encroaching slightly on the base of the vessel shadow.

In mitral patients (mitral stenoses of rheumatic origin) the changes in the left auricle are of prime importance in semiology and prognosis; it is therefore necessary to fix their appearance and characteristics accurately and to make them readily accessible and appreciable. We have therefore described four chief appearances which correspond to the progressive stages of increase in the size of the auricle. As is known this generally takes place toward the right; the left auricle first increases directly backward, then as soon as it comes in contact with the spinal column it glides over on its right side and spreads freely toward the costovertebral groove and the right half of the thorax. In the course of this migration roentgen observation in the frontal position shows the four following appearances:

(1) A double outline due to the presence within the heart shadow of a more opaque disc, the right outline of which doubles the right outline of the silhouette on the inside. This appearance shows the enlargement of the left auricle *backward only*.

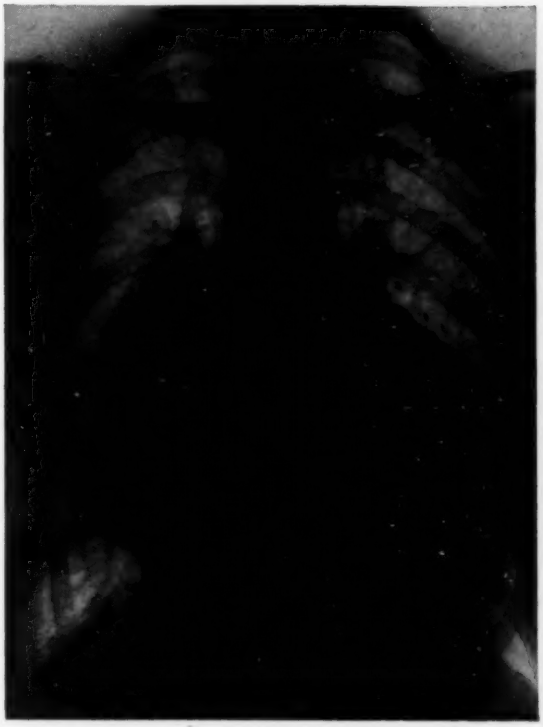


Fig. 4. Male, aged, thirty-seven. Progressive mitral rheumatic endocarditis, complete arrhythmia. The left auricle, which is quite large, has developed progressively toward the right. Shortly before death its frontal projection covered and passed beyond the cardiopedicular angle and the right hilum and almost the whole of the right border of the heart in a double contour image (left auricle outside).

Fig. 3. Male, aged thirty. Progressive rheumatic endocarditis with mitral and aortic valvulitis; regular rhythm. The left auricle, very much enlarged, has developed toward the right; in the frontal position its projection emerges into the right cardiopedicular angle and, pushing aside the right hilum forms a double festoon image with the right border of the heart (right auricle). The bifurcation of the trachea is displaced.

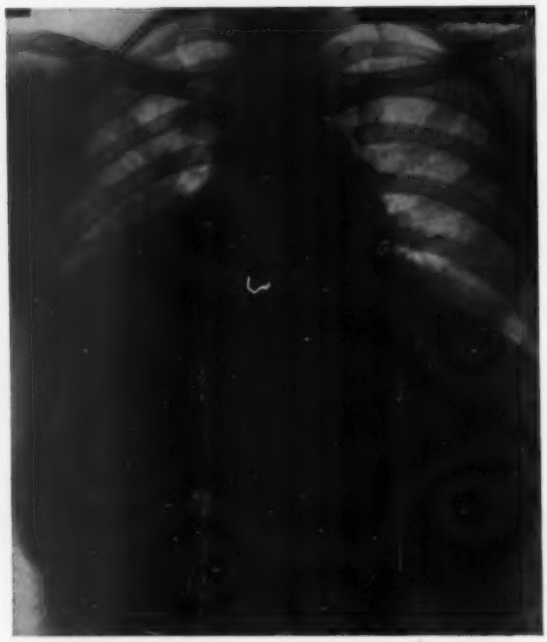


FIG. 5. Female, aged fifty-five. Rheumatic endocarditis progressing for twenty-five years; at present complete arrhythmia and marked insufficiency of the heart; aneurysmal dilatation of the left auricle which is of considerable size (capacity 1 to 2 liters). This cavity occupies all the base of the right hemithorax, reaching the right wall of the thorax, pushing the esophagus to the left, raising the bifurcation of the trachea to horizontal and compressing the bronchi.

(2) The appearance of a double festoon beginning at the right arch of the diaphragm and formed by the right arch of the general outline of the heart, and then above that another arch which is the outer boundary of the darker disc described above. But this disc, instead of remaining enclosed in the silhouette, has projected beyond it to the right, and the right border of the silhouette is therefore formed of two segments of an arc, resulting from the intersection of the two circles; it is these two segments of the arcs which we call the double festoon.

(3) A double outline with a large heart, caused this time by the exaggerated projection of the left auricle toward the right; the left auricle, very much dilated, has increased its migration into the right hemithorax, backward and to the right, and in roentgenoscopy and relative teleroentgenography the right outline of the conical projection is outside the right outline of the heart. The shadow of the left auricle passes entirely beyond the outline of the right auricle. This double outline is the inverse of the first picture, the right auricle being inside and the left auricle outside. In these cases the whole heart silhouette is always very large, which is far from being the case usually in double outline number one.

(4) Very large heart with a considerable projection to the right, corresponding to the enormous dilatation of the left auricle called aneurysmal. There is no longer a double outline because the right auricle is entirely enclosed in the left auricle which alone forms more than three-fourths of the whole heart mass.

In some exceptional cases the left auricle instead of developing toward the right de-

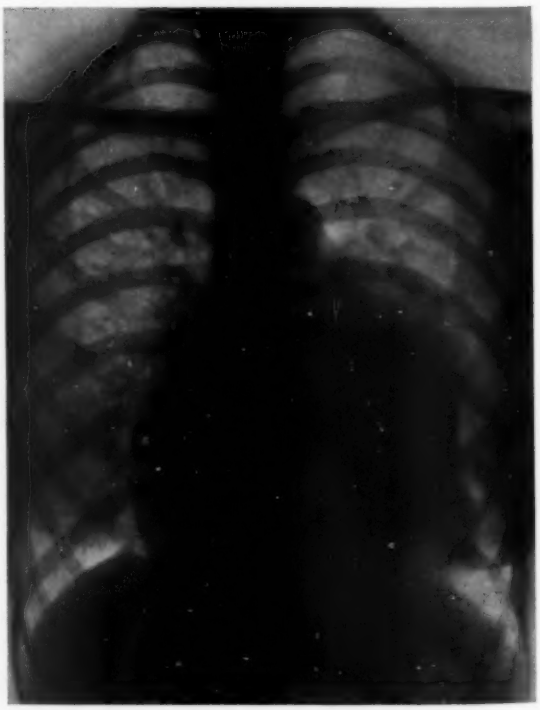


FIG. 6. Female, aged twenty-five. Rheumatic mitral endocarditis which has progressed to complete arrhythmia. The left auricle has *migrated to the left* (exceptional case); in the frontal position its projection emerges from the heart mass into the cardiopedicular angle, forming a left double festoon image with the left border of the heart.

velops toward the left. Its left outline then passes beyond the left outline of the heart silhouette and a double outline of the middle arch is seen. In these cases the rotation of the heart takes place from left to right, in the direction opposite to that usually imposed by the development of the large auricle toward the right, and the right outline is therefore decreased.

By its increase in size the left auricle modifies the relations and appearance of two groups of organs near it. First, the shadow of the right hilum is pushed upward; then the division of the trachea is pushed apart more, is more open; finally the left bronchus, rendered more horizontal and more curved, undergoes a flattening of its lumen from the pressure of the auricle.

All these appearances, discernible ordinarily by simple roentgenoscopy, are particularly evident on roentgenograms. It is always advisable to opacify the esophagus which, because of its intimate relations with the left auricle, marks its posterior outline distinctly. This analysis of the different appearances of the left auricle in the frontal position in mitral patients makes it possible to supplement the results of examination in the oblique positions.

REFERENCES

1. Routier, D., and Heim de Balsac, R. Constitution du bord droit du pédicule en position frontale. *Bull. et mém. Soc. de radiol. méd. de France*, 1936, *24*, 633–640.
2. Laubry, C., Routier, D., and Heim de Balsac, R. Visibilité de l'oreillette gauche en frontale au sein de la silhouette cardiaque. *Bull. Acad. de méd.*, 1937, *117*, 628–636.
3. Routier, D., and Heim de Balsac, R. Roentgenologic anatomic study of left auricle following post-mortem opacification. Am. J. Roentgenol. & Rad. Therapy, 1938, *40*, 838–847. (See this article for previous references.)

THE ORIGIN OF TUMORS OCCURRING IN THE APEX OF THE LUNG*

By WENDELL C. HALL, M.D.
HARTFORD, CONNECTICUT

DURING the past several years considerable controversy has arisen over the origin of tumors occurring in the apex of the lung, chiefly as a result of two articles by Pancoast, who believed that he might have found a new entity among intrathoracic tumors to which he gave the name of "superior pulmonary sulcus tumor." In the present article most of the world literature on this subject has been reviewed briefly, and 5 selected cases of tumors occurring in the apex of the lung have been added in an effort to clarify the question as to the origin of these tumors.

LITERATURE

Ricaldoni[41] in 1918 reported an apical lung tumor which he was convinced arose from "the pleural dome." This tumor was typical of those described at a later date by Pancoast. In 1924 Pancoast[34] reported 3 apical lung tumors, and at that time he expressed the opinion that he might be dealing with a previously unrecognized type of intrathoracic cancer. Tobias,[53] in 1931, evidently unaware of Pancoast's report, added 5 similar cases to the literature, in one of which the apical tumor was a metastasis from a carcinoma of the stomach. In the same year da Rin[8] and Courcoux and Lereboullet[6] each reported a bronchial cancer in the apex of the lung. Neither of these cases showed rib erosion but they otherwise closely resembled Pancoast's cases.

In 1932 Pancoast[35] wrote a second article in which he reviewed his previous 3 cases and added 4 more, to all of which he gave the name of "superior pulmonary sulcus tumor" in the belief that he might be dealing with a new type of tumor in the apex of the lung. Unfortunately autopsies were not obtained on any of his patients, and biopsies were done on only two. Theorizing as to the origin of the tumors, he felt that the possibility of primary lung cancer could almost be eliminated because he had never seen one of them produce Horner's syndrome as an early manifestation. One of the biopsies showed spinocellular carcinoma and the pathologist, Dr. McFarland, also felt that a tumor of this type, so far from the larger bronchi, was not likely to be primary in the lung. Having thus come to the conclusion that primary lung tumors could practically be excluded, Pancoast advanced the thought that perhaps the tumors might have arisen from embryonic branchiogenic rests, and hence that they might be a previously unrecognized type of apical lung tumor. From a study of his cases he laid down the following criteria for the diagnosis of a superior pulmonary sulcus tumor: (1) it has a definite location at the thoracic inlet and it gives roentgen evidence of a small homogeneous shadow in the apex of the lung; (2) it causes pain in the shoulder, often radiating down the arm, together with atrophy of various muscles of the upper extremity on the side of the lesion; (3) it produces Horner's syndrome on the involved side; (4) it always produces more or less local rib destruction which is limited to the first three ribs, and this is at times associated with vertebral infiltration; and (5) death occurs as a result of a comparatively trivial growth without detectable roentgen evidence of metastasis. Pancoast recognized the fact that tuberculosis in the apex of the lung might give some but not all of the signs and symptoms needed for a diagnosis of superior pulmonary sulcus tumor. He also recognized the fact that primary lung tumors and osteogenic sarcomas occur in the apex, but he felt that they could be excluded from the class of superior pulmonary sulcus tumors because he had not seen any of

* From the Department of Radiology, Temple University Hospital, Philadelphia.

them which fulfilled all of his requirements. This, however, does not constitute a sound basis for exclusion since theoretically these tumors or any other malignant tumor in the apex, primary or metastatic, could conform to his criteria. Well aware of the fact that his cases were incompletely studied, he wisely concluded that additional knowledge from a more thorough study of other cases might make it necessary to abolish the term "superior pulmonary sulcus tumor" as implying a specific tumor in the apex.

Pardal[36] in 1932 reported a carcinoma of the lung occurring in the apex and having all the characteristics which Pancoast stressed. Several reports appeared in 1933. Sperling and Yaskin[49] described an apical neoplasm which they called a superior pulmonary sulcus tumor after Pancoast. Pardal, Ferrari, and Itoiz[38] found a primary carcinoma in the left apex of the lung when their patient was autopsied, and Pardal and Brea[37] reported a case in which they thought the tumor was bronchial in origin. Bartstra and Fortanier[2] felt that the apical tumor in their patient might very well have arisen from a fifth branchial cleft representing a displaced embryonic rest.

Clarke[4] reported a typical superior pulmonary sulcus tumor in 1934. He saw nothing to lead him to believe that the tumor might have arisen from a branchial cleft but he could not rule out the possibility of a primary lung tumor, although he was unable to trace any connection with a bronchus. It was his opinion that the symptom-complex of this tumor quite likely did not represent any specific type of cancer. In discussing his paper Karsner described an apical lung tumor in which a tentative diagnosis of sympathicoblastoma had been made. In the same discussion Weston mentioned a dural endothelioma which had arisen in the cord at the level of the apex, producing the signs and symptoms of a superior pulmonary sulcus tumor.

Jacox[21] gave an account of 2 cases in 1934 and concluded that superior pulmonary sulcus tumors were probably an atypical form of primary bronchogenic carcinoma. In the same year Fried[12] reported a case of primary apical lung cancer and stressed the fact that various malignant tumors in the apex might give the signs and symptoms described by Pancoast. In the following year he reported a squamous cell epithelioma in the apex arising from a tuberculous lesion in the upper lobe,[13] and also 2 cases[14] in which he believed that the tumors might have arisen from epithelial rests of the lower cleft of the branchial apparatus. Steiner and Francis[52] concluded in 1934 that their 3 cases all had an intrapulmonic origin. Browder and DeVeer[3] reviewed the literature in 1935 and added 5 cases of their own, arriving at the conclusion that the symptom-complex of a superior pulmonary sulcus tumor did not represent either a clinical or a pathological entity among tumors. Two of their apical tumors were metastases, one probably from a primary bronchogenic carcinoma, and the other probably from a hypernephroma. Two more were primary in the lung, and the fifth had its origin in the mediastinum. Frost and Wolpaw[15] expressed an opinion similar to that of Browder and DeVeer in 1936 when they reported a sympathicoblastoma in the apex. In the same year Marcil and Crawford[31] concluded that superior pulmonary sulcus tumors were primary carcinomas of the lung.

According to Moschcowitz[32] in 1937, studies made in the laboratory of Mt. Sinai Hospital have definitely established the fact that most squamous cell tumors of the apex arise from terminal bronchi, and that peripheral tumors of this type are by no means limited to the apex. He was of the opinion that Pancoast's tumors arose from terminal bronchi in the superior aspect of the lung.

A long symposium on apical lung tumors was held in South America in the latter part of 1937 during which most of the world literature on the subject was reviewed, but nothing was added to what has been said above.

A diversity of opinions has thus been ex-

pressed by various authors, a few of them taking the stand that there is a specific tumor in the apex which gives the signs and symptoms described by Pancoast, others believing that these tumors are all primary lung tumors, and still others being of the opinion that there is no specific type of tumor in the apex which conforms to the criteria set forth by Pancoast. The weight of evidence shows that most apical tumors are primary in the lung but that other primary tumors, as well as metastatic tumors, occur in this region, and that any of them can simulate the tumors described by Pancoast.

CLINICAL APSECTS

Tumors in the apex of the lung may be primary or metastatic. In either case they give certain rather characteristic signs and symptoms due to early involvement of the brachial plexus and the cervical sympathetic, both of which are in close proximity to this area. Pain in the shoulder region is usually the first complaint of the patient. This pain frequently becomes quite severe, radiating down the arm and eventually into the fingers, most often in the ulnar nerve distribution. Upper thoracic nerve roots outside the brachial plexus may also be involved. Concurrently, various muscle groups in the extremity may become paralyzed and atrophied, the muscles of the hand frequently being affected. Paralysis of the cervical sympathetic results in drooping of the upper eyelid, enophthalmos, and myosis on the involved side. The drooping of the upper lid is actually a pseudoptosis resulting from paralysis of the non-striated part of the levator palpebrae, and the lid can be lifted voluntarily to its full extent, since the voluntary striated fibers of the levator are unaffected. The enophthalmos is attributed by some to paralysis of the non-striated orbitalis muscle of Müller, and the myosis is due to paralysis of the dilator pupillae muscle. Although the affected pupil does not dilate when shaded, it contracts briskly to light and on convergence, since the third cranial nerve which controls the sphincter pupillae is unaffected. Paralysis of the cervical sympathetic also results in loss of perspiration on the affected side of the head and neck including the shoulder and the upper extremity of that side. These changes will be recognized as the well known Horner's syndrome. An irritation stage might precede the paralytic stage, giving the opposite neurological changes; i.e., wide palpebral fissure, exophthalmos, dilatation of the pupil, and excessive sweating on the involved side. Occasionally the recurrent laryngeal nerve is involved, and paralysis of the larynx with hoarseness has been reported in a few instances.

Roentgenograms show a soft tissue shadow in the apex of the lung which usually appears small and insignificant compared with the symptoms of the patient. Frequently but not invariably physical signs can be detected over the apex. Erosion of the posterior portions of the upper ribs is almost always present, the first three ribs being most commonly involved, although the fourth and fifth may also be eroded. Bone destruction in adjacent vertebrae may take place at a later date, and cord signs and symptoms usually appear if the patient lives long enough.

Most primary apical lung tumors occur in men. They produce excessive weight loss but seldom cause cough or hemoptysis. Not infrequently they give rise to metastases. The life expectancy from such tumors, regardless of origin, is short, usually a year or less. They do not respond to irradiation.

CASE HISTORIES

Five cases of apical lung tumor have been selected to illustrate some of the different types of cancer in the apex which produce the signs and symptoms characteristic of tumors in this region.

CASE 1. M. M., a white male, aged sixty-four, in April, 1934, developed sudden sharp pain between the shoulders, radiating down the back and both arms to the fingers. The pain was much worse on the right side. He lost 34 pounds between April and September when he was admitted to the Pennsylvania Hospital. At the time of admission he had a typical Horner's

syndrome on the right side, in addition to wasting of the muscles of the right shoulder girdle, weakness of the right triceps and biceps muscles, and wasting of the forearm muscles and of the thenar and hypothenar eminences of the right hand. There was also some evidence of a cord lesion in the upper thoracic region with slight neurological changes in the left arm and in the lower extremities. A hard mass could be seen and palpated in the right supraclavicular space. Roentgen examination of the chest at this time (Fig. 1) showed a lesion in the right apex with considerable destruction of the posterior portions of the third and fourth ribs and some destruction of the fifth rib. The right border of the fourth thoracic vertebra was also eroded. Due to the fact that the patient had had slight difficulty in swallowing for one month he was given some barium and this unexpectedly showed a large carcinoma in the lower part of the esophagus (Fig. 2). It was immediately assumed that the lesion in the apex represented a metastasis from the lesion in the esophagus. The patient died of pneumonia on October 3, 1934, and postmortem examination showed a large carcinoma of the lower third of the esophagus with metastasis to mediastinal lymph nodes, right apex, right posterior chest wall, and upper thoracic vertebrae.

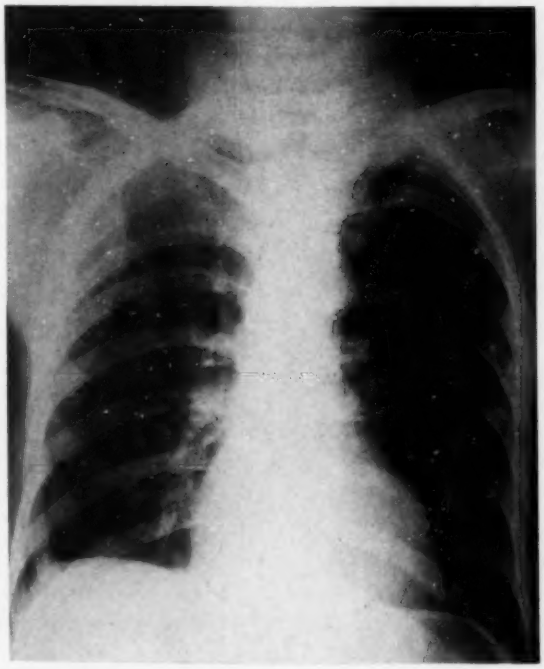


Fig. 1. Case 1. Metastatic carcinoma in the right apex. The primary lesion was in the esophagus.

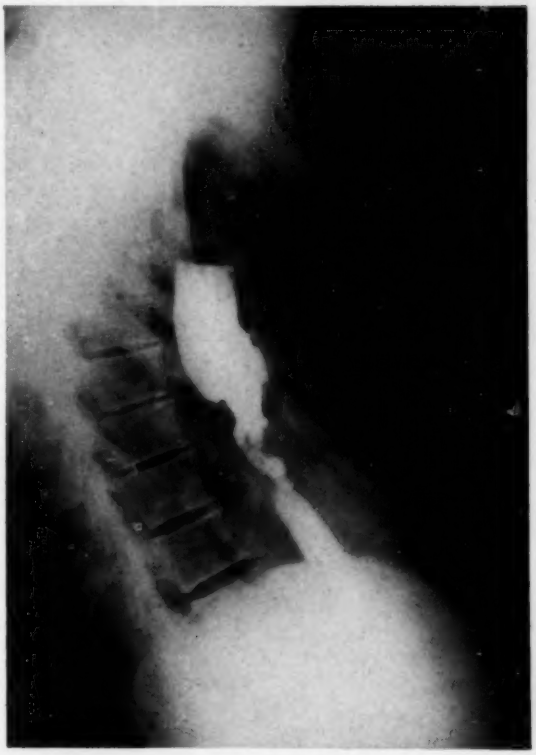


Fig. 2. Case 1. Primary carcinoma of the esophagus. This tumor metastasized to the right apex of the lung as shown in Figure 1.

Comment. This case demonstrates the fact that a metastatic tumor in the apex of the lung can give the same signs and symptoms as a primary tumor in this area. Rebattu[42] and Rendu[43] in 1932 each described esophageal cancers metastasizing to the neck and producing sympathetic involvement. The above case, however, is the only one which can be found in the literature in which an esophageal cancer has metastasized to the apex of the lung, producing the signs and symptoms of other apical lung tumors with rib erosion and involvement of the cervical sympathetic and brachial plexus.

Case II. H. W., aged fifty-one, was admitted to Temple University Hospital on June 30, 1937, with severe pain in the left arm. This had been increasing in severity since the onset almost one year previously. Three months before admission he had noticed some trouble with vision, drooping of the left eyelid, gradual loss of strength in the left upper extremity, and

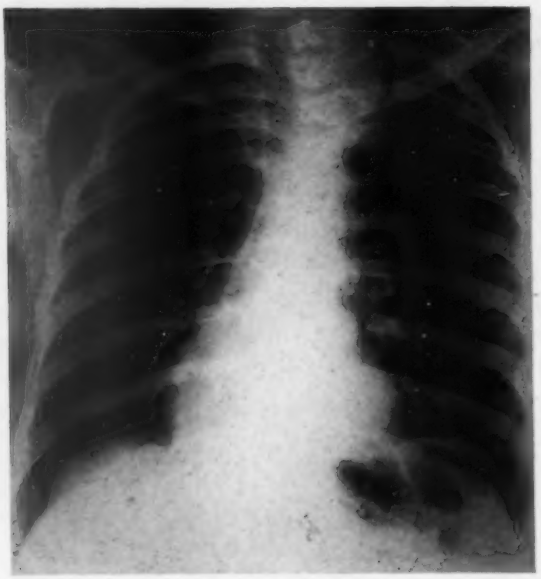


Fig. 3. Case II. Primary adenocarcinoma of the lung arising in the apex.

numbness on the outside of the left forearm. He had lost 40 pounds since the onset of the illness.

The neurological examination showed Horner's syndrome on the left side. There was also atrophy of some of the muscles of the left upper extremity, including the thenar and hypothenar eminences of the hand.

Roentgen examination on June 17, 1937 (Fig. 3) showed a malignant tumor in the apex of the left lung with destruction of the left pedicles and of the left lateral surfaces of the first and third dorsal segments but without as yet any rib destruction. These bone changes are better shown by the stereoscopic films than by the illustrations.

A cordotomy was done several days after admission for relief of pain and the patient died rather suddenly a day or two following the operation. Autopsy showed a firm tumor mass filling the superior sulcus of the left lung with some involvement of the lung tissue and of the mesial periosteum of the left clavicle and first rib, and with erosion of the seventh cervical and first and second thoracic vertebrae. Microscopic section showed adenocarcinoma. The tumor appeared to be bronchogenic in origin, and metastases were found in the dura of the brain and in both adrenals.

Comment. Most malignant tumors in the superior pulmonary sulcus are primary lung tumors, of which this is a typical example. It is not uncommon for lung tumors, as in this case, to metastasize to the brain and to the adrenals.

Case III. J. D., a male, aged fifty-nine, developed pain in the right shoulder radiating down the inner side of the right arm into the middle and ring fingers in September, 1935. He had a typical Horner's syndrome on the right side. There was a fullness in the right supraclavicular fossa with atrophy of the intrinsic muscles of the right hand and weakness of the right upper extremity. There was also loss of pain sensation in the distribution of C-8 and T-4 with preservation of touch and vibratory sensation.

Roentgen examination (Figs. 4 and 5) on May 12, 1936, showed a dense soft tissue mass in the extreme apex with destruction of the posterior portion of the right third and of the vertebral portion of the right second rib, in addition to erosion of the lateral aspects of the second and third thoracic vertebral bodies. Roentgen therapy was given without any beneficial effect.

The patient died of bronchopneumonia on July 31, 1936, approximately ten months after

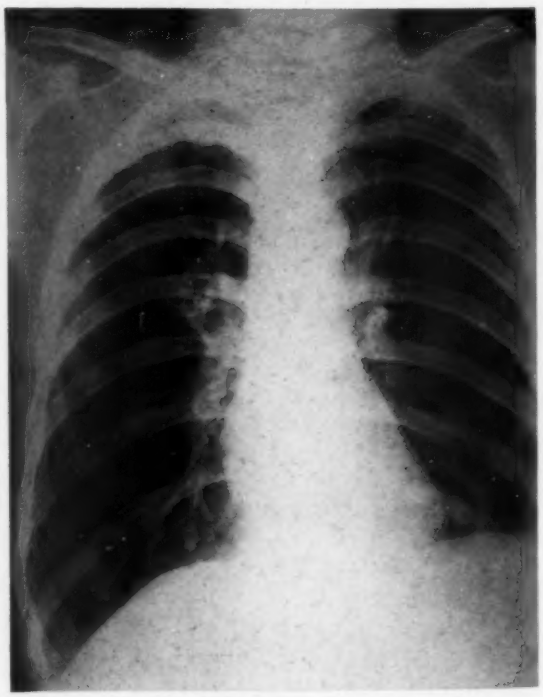


Fig. 4. Case III. Metastatic carcinoma of the right apex. This tumor was primary in the stomach.

onset of symptoms. Autopsy showed a small scirrhous carcinoma of the stomach with metastasis to the left adrenal and to the apex of the lung.

Comment. This case demonstrates another type of metastasis occurring in the apex of the lung, and it shows that the rather characteristic signs and symptoms which Pancoast described are not distinctive of any specific tumor in this region. Tobias had a similar case in 1931.

Case iv. J. L., male, aged sixty-three, was admitted to Temple University Hospital complaining of pain which involved the right side of the chest and which had been growing worse since the onset in April, 1935. He was discharged on January 28, 1936, but readmitted on March 3, 1936, with severe pain in the right lower chest anteriorly radiating to the right axilla.

The neurological examination at the last admission showed narrowing of the right palpebral fissure and myosis of the right pupil with slight deviation of the tongue to the left and loss of vibratory sense in the lower extremities.

The roentgen examination on December 20, 1935, showed a soft tissue density in the right apex, thought to represent pleural thickening. A triangular shadow in the mesial, caudal and dorsal area of the right lung space was suspicious of atelectasis and a carcinoma involving the lower lobe bronchus was suspected. In a subsequent roentgen examination of the chest on December 28, 1935 (Fig. 6) a soft tissue density having very much the appearance of a metastatic nodule was found in the left hilum. No evidence of skeletal metastasis was found.

Fig. 5. Case iii. Same as Figure 4 but showing rib destruction.

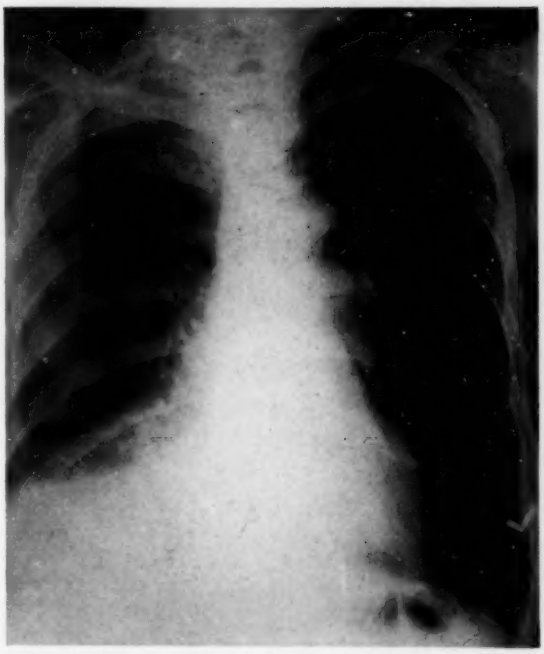


Fig. 6. Case iv. Carcinoma in the right apex, probably primary in the lung.

The patient died on April 12, 1936. Autopsy showed adhesions between the apex of the right lung and the chest wall and a large irregular round fibrous growth measuring approximately 10 cm. in diameter in the apex, involving the parietal pleura, the ribs, and the lateral aspects of the vertebrae. Numerous firm white metastatic growths were found on the vertebrae and ribs. The third rib on the right side in particular was involved, along with the sixth, seventh and eighth. Several large nodular metastatic masses were present on the upper surface of the right dome of the diaphragm and metastases were found in both adrenals. Dissection of the bronchi revealed no evidence of tumor growth. A microscopic section from the tumor in the apex showed a primary carcinoma of an atypical type.

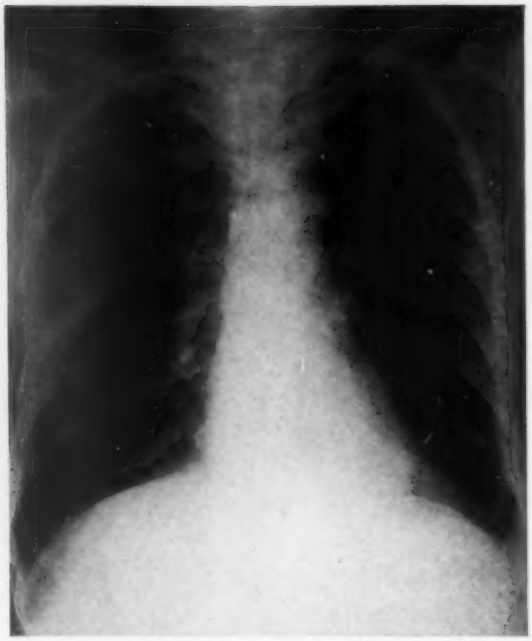


Fig. 7. Case v. Tumor in the right apex and partial destruction of the sixth rib on this side by metastasis.

Comment. Inability to trace any connection between this tumor and the bronchial tree has left some doubt as to its point of origin. Cases of this type have caused most of the confusion in the past, leading several investigators to believe that they were dealing with a new kind of tumor in the apex which was capable of producing specific signs and symptoms by which it could be identified. This is probably a primary lung tumor. Regardless of origin, it has no characteristics which distinguish it from any other malignant tumor in this region.

Case v. A. W., a male, aged fifty, was admitted to Temple University Hospital complaining of pain in the right shoulder and axilla, radiating down the right arm to the hand. This pain had gradually increased in severity since the onset almost four years previously, and the patient had recently noticed some pain in the left arm.

Physical examination showed enlargement of the thyroid, the tumor being soft, movable, and smooth in outline, with no suggestion of malignancy. A neurological examination showed weakness of the right upper extremity with definite bilateral impairment to pain sense below T-2. The findings indicated a lesion involving the spinal cord under the laminae of T-1 and T-2. Although the patient did not have Horner's syndrome, the right pupil was dilated on one or two occasions, suggesting irritation of the sympathetic.

Roentgen examination (Figs. 7 and 8) on September 28, 1938, showed a soft tissue lesion in the right apex. The transverse processes and pedicles of the seventh cervical and first thoracic vertebrae and the posterior portion of the first rib on this side were partially destroyed. There was almost complete destruction of the posterior and lateral third of the right sixth rib, and the fourth, fifth and seventh ribs on this side were probably involved. The pedicle of the ninth thoracic vertebra on the right side showed marked demineralization. These changes can be seen much better on the stereoscopic films than in the illustrations. There was also roentgen evidence of metastasis to the skull and pelvis.

Some brown pigmented material was obtained from a biopsy of the sixth rib on the right side. A needle biopsy was done on the right transverse process of the first thoracic vertebra on October 12, 1938. The material from both of

Fig. 8. Case v. Same as Figure 7 but showing the tumor in the right apex more clearly.

these biopsies showed large foam cells and a diagnosis of malignant metastasizing chromaffinoma was made by the pathology department. Approximately three months later a thyroidectomy was done and a carcinoma of the thyroid was found.

Comment. The chances are against this patient having two different malignant tumors, and in all probability he has a carcinoma of the thyroid which has metastasized to the right apex and to the various bones. This same opinion was expressed by Dr. Smith in the pathology department, although he felt that the histology was sufficiently distinct in the two tumors to make him hesitate to abandon the diagnosis of two separate tumors—a chromaffinoma in the right apex and a carcinoma of the thyroid. The patient is still alive. Perhaps an autopsy will eventually make it clear whether he has a chromaffiinoma in the right apex or a metastatic carcinoma from the thyroid in this region.

CONCLUSIONS

A review of the literature on apical lung tumors, to which five illustrative cases are added, shows that there is no specific tumor in the apex of the lung which will give characteristic signs and symptoms to the exclusion of other types of cancer. Primary lung tumors, sympathicoblastomas, endotheliomas, perhaps tumors arising from embryonic branchial rests, and various metastatic tumors have all been described in the apex of the lung, conforming completely or rather closely to certain characteristics which may be found in any malignant tumor occurring in this region.

Acknowledgment is due Dr. Paul A. Bishop at the Pennsylvania Hospital for permitting the use of Case 1.

REFERENCES

1. Anderson, J. A., and Shennan, T. A neuroblastoma of the thoracic cavity. *J. Path. & Bact.*, 1923, *26*, 545–546.
2. Bartstra, D. S., and Fortanier, A. H. Case of malignant tumor at apex of lung. *Nederl. tijdschr. v. geneesk*, 1933, *77*, 4111–4114.
3. Browder, J., and DeVeer, J. A. Varied pathologic basis for symptomatology produced by tumors in the region of the pulmonary apex and upper mediastinum. *Am. J. Cancer*, 1935, *24*, 507–521.
4. Clarke, B. E. Superior pulmonary sulcus tumor (Pancoast). *Am. J. Path.*, 1934, *10*, 693–696.
5. Connolly, A. E. Superior pulmonary sulcus tumour. *Brit. J. Radiol.*, 1935, *8*, 781–786.
6. Courcoux, A., et Lereboullet, J. Syndrome phrénico-pupillaire avec paralysie du plexus brachiale dans un cas de cancer du poumon avec tuberculose associée. *Arch. méd.-chir. de l'app. respir.*, 1931, *6*, 569–579.
7. Craver, L. F., and Blady, J. V. An unusual case of bilateral pulmonary apical dermoid cysts. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 205–209.
8. Da Rin, C. Sindrome de Claudio Bernard-Horner en la evolución de un epitelioma del lóbulo superior del pulmón izquierdo. *Semana méd.*, 1931, *2*, 81–91.
9. Davidsohn, I., and Feldman, L. The so-called superior pulmonary sulcus tumor. *Tr. Chicago Path. Soc.*, 1937, *15*, 16–17.
10. Dobrzaniecki, W., et Stankiewicz, S. Tumeur de cou et du médiastin antérieur de provenance sympathique (ganglio-neurome). *J. de chir.*, 1936, *48*, 785–791.
11. Eyherabide, R. A. A propósito de la discusión sobre el sindrome ápico-costo-vertebral doloroso. *Rev. Asoc. méd. argent.*, 1937, *51*, 481–482.
12. Fried, B. M. Bronchiogenic cancer; treatment with roentgen rays. *Am. J. Cancer*, 1934, *20*, 791–806.
13. Fried, B. M. Bronchiogenic cancer combined with tuberculosis of the lungs. *Am. J. Cancer*, 1935, *23*, 247–266.
14. Fried, B. M. Sternoclavicular branchioma. *Am. J. Cancer*, 1935, *25*, 738–745.
15. Frost, T. T., and Wolpaw, S. E. Intrathoracic sympathoblastoma producing the symptomatology of a superior pulmonary sulcus tumor (Pancoast). *Am. J. Cancer*, 1936, *26*, 483–492.
16. Glomset, D. A. Incidence of metastasis of malignant tumors to the adrenals. *Am. J. Cancer*, 1938, *32*, 57–61.
17. Graef, I., and Steinberg, I. Superior pulmonary sulcus tumor. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 293–300.
18. Gravano, L., and Bianchetti, S. L. A propósito de una nueva observación con el síndrome ápico-costo-vertebral doloroso. *Rev. Assoc. méd. argent.*, 1937, *51*, 439–442.
19. Gravano, L., and Malenchini, M. Importancia de la tomografía pulmonar en el diagnóstico del tumor apexiano. Sindrome ápico-costo-vertebral doloroso. *Rev. Assoc. méd. argent.*, 1937, *51*, 509–512.

20. GUILLAIN, G., and STERNE, J. La forme neurologique du cancer de l'apex pulmonaire. Paralysie douloureuse du plexus brachial avec syndrome de Claude Bernard-Horner. *Ann. de. méd.*, 1936, *40*, 93–105.
21. HABEIN, H. C., MILLER, J. M., and HENTHORNE, J. C. Tumors of the pulmonary apices and adjacent regions involving the brachial plexus. *Ann. Int. Med.*, 1938, *11*, 1806–1817.
22. HARE, E. S. Tumor involving certain nerves. *London Med. Gaz.*, 1838, *23*, 16–18.
23. HENDERSON, W. F. Roentgen study of apical chest tumors. *Am. J. Surg.*, 1930, *8*, 414–420.
24. JACOX, H. W. Superior pulmonary sulcus tumor. *J. Am. M. Ass.*, 1934, *103*, 84–87.
25. JACOX, H. W., and BAKER, M. R. Primary apical lung cancer producing symptomatology of a superior pulmonary sulcus tumor. *Radiology*, 1937, *29*, 525–529.
26. KELMAN, H., and SCHLEZINGER, N. S. Tumor of the superior thoracic inlet (Tumor of the superior pulmonary sulcus). *Arch. Path.*, 1937, *23*, 383–391.
27. LLOYD, M. S., Sympathico-blastoma of the second dorsal sympathetic ganglion. *Am. J. Surg.*, 1935, *29*, 477–478.
28. LÓIZAGA, N. S., and VIVOLI, D. Tuberculosis pulmonar y cáncer de bronquio. *Semana méd.*, 1934, *1*, 2022–2029.
29. LOPEZ FERNANDEZ, F., and FUSTE, R. Carcinoma primitivo del pulmón, ofreciendo et cuadro de un "sindrome de Pancoast." *Rev. méd. cubana*, 1937, *48*, 1106–1112.
30. LUSE, H. D. Bilateral malignancy of the adrenal glands with metastases into the left lung. *M. Bull. Vet. Admin.*, 1935, *12*, 76–77.
31. MARCIL, G. E., and CRAWFORD, B. L. Primary carcinoma of the lung occurring in the apex. *Am. J. Cancer*, 1936, *26*, 137–143.
32. MOSCHOWITZ, E. Superior sulcus tumor. *J. Mt. Sinai Hosp.*, 1937, *3*, 198–200.
33. OLIVER, R. L. Malignant epithelial tumors of the neck. Carcinoma of branchiogenic origin. *Am. J. Cancer*, 1935, *23*, 16–44.
34. PANCOAST, H. K. Importance of careful roentgen-ray investigations of apical chest tumors. *J. Am. M. Ass.*, 1924, *83*, 1407.
35. PANCOAST, H. K. Superior pulmonary sulcus tumor. *J. Am. M. Ass.*, 1932, *99*, 1391–1396.
36. PARDAL, R. Cáncer de vértice pulmonar. Sindrome ápico-costo-vertebral doloroso y anginosa. *Rev. Asoc. méd. argent.*, 1932, *46*, 913–919.
37. PARDAL, R., and BREA, M. M. Cáncer de ápex tóraco-pulmonar. *Semana méd.*, 1933, *2*, 677–682.
38. PARDAL, R., FERRARI, R. C., and ITOIZ, A. Cáncer de vértice pulmonar, con lesiones coexistentes de tuberculosis. Sindrome de Déjèrine-Klumpke y metastasis vertebral. *Semana méd.*, 1933, *2*, 1409–1419.
39. PEIRCE, C. B. Extra-pulmonary tumors of the thorax. *Radiology*, 1935, *24*, 467–479.
40. PURVES-STEWART, SIR JAMES. The Diagnosis of Nervous Diseases. Sixth edition. Edward Arnold & Co. 1924, pp. 308–314 and 445–454.
41. RAIMONDI, A. A., and PARDAL, R. Endotelioma de pleura y sindrome de Pourfour de Petit. *Rev. Assoc. méd. argent.*, 1932, *46*, 385–397.
42. REBATTU. Paralysie récurrentielle bilatérale et syndrome de Claude Bernard-Horner, au cours de l'évolution d'un cancer de l'oesophage. *J. de méd. de Lyon*, 1932, *13*, 445–447.
43. RENDU, R. Syndrome oculo-sympathique paralytique et cancer oesophagien. *Lyon méd.*, 1932, *150*, 547–551.
44. RICALDONI, A. Paralisis atrofica radicular inferior del plexo braquial por esclerosis epiteliomatosa procedento del domo pleural en el curso de un cancer latente del pulmon. Las lesiones irradientes del domo pleural. *Anales de la Facultad de medicina*, Montevideo, 1918, p. 770.
45. ROMANO, N., and EPHERABIDE, R. A. Consideraciones sobre el síndrome ápico-costo-vertebral doloroso. *Rev. Asoc. méd. argent.*, 1937, *51*, 442–447.
46. ROMANO, N., and EPHERABIDE, R. A. Análisis critico de la monografía del Dr. J. W. Tobias. Sindrome ápico-costo-vertebral doloroso. Su valor diagnóstico en el cáncer primitivo pulmonar. *Rev. Asoc. méd. argent.*, 1937, *51*, 482–488.
47. ROMANO, N., and EPHERABIDE, R. A. El cáncer del vértice toraco-pulmonar en la bibliografía mundial consultada. *Rev. Asoc. méd. argent.*, 1937, *51*, 488–501.
48. ROMANO, N., and EPHERABIDE, R. A. A propósito de la discusión sobre el sindrome ápico-costo-vertebral doloroso. *Rev. Asoc. méd. argent.*, 1937, *51*, 505–508.
49. SPERLING, S. J., and YASKIN, J. C. Superior pulmonary sulcus tumor. *Arch. Neurol. & Psychiat.*, 1933, *30*, 694–696.
50. STEIN, J. J. Clinical and pathological features of tumors occurring in the region of the apex of the lung. *Texas State J. Med.*, 1937, *33*, 293–299.
51. STEIN, J. J. Apical lung tumors. Further observations with report of seven additional cases. *J. Am. M. Ass.*, 1938, *111*, 1612–1617.
52. STEINER, P. E., and FRANCIS, B. F. Pulmonary apical lung carcinoma. *Am. J. Cancer*, 1934, *22*, 776–785.
53. TOBIAS, J. W. Sindrome apico-costo-vertebral doloroso. Tesis de Profesora de Buenos-Aires, 1931.
54. TOBIAS, J. W. Sindrome de métastasis costo-vertebral superior. *Semana méd.*, 1931, *1*, 1479.

55. Tobias, J. W. Sindrome ápico-costo-vertebral doloroso por tumor apexiano. Su valor diagnostico en el cáncer primitiva polmonar. *Rev. méd. latino-am.*, 1932, *17*, 1522–1556.

56. Tobias, J. W. A propósito de la discusión sobre el sindrome ápico-costo-vertebral doloroso. Nueva contribución al estudio de los tumores apicales del pulmón. *Rev. Asoc. méd. argent.*, 1937, *51*, 447–475; 503–505.

57. Tobias, J. W. Réplica a la segundo y tercera parte de la discusión del Dr. Eyherabide. *Rev. Asoc. méd. argent.*, 1937, *51*, 502.

58. Tobias, J. W. Cierre de la discusión sobre el sindrome ápico-costo-vertebral doloroso. *Rev. Asoc. méd. argent.*, 1937, *51*, 509.

59. Tobias, J. W., and Itoiz, O. A. Cáncer del ápex torácico secundario a un carcinoma de la mama (su comprobación anátomopatológica). *Rev. Asoc. méd. argent.*, 1937, *51*, 476–482.

60. Tobias, J. W., and Cammarota, A. Algunas consideraciones anátomoclínicas sobre los tumores del ápex tóraco-pulmonar, o tumores apexianos. *Rev. Asoc. méd. argent.*, 1938, *52*, 273–275.

"CYSTIC" DISEASE OF THE LUNG*

By CARLETON B. PEIRCE, A.B., M.Sc., M.D.
Royal Victoria Hospital
MONTREAL, CANADA

GRAPHIC variations from the normal roentgenologic pattern of any structure occasionally give rise to dogmatic conclusions. The frequent reports of "congenital pulmonary cyst," "congenital cystic disease of the lung," " congenital cyst of the lung," "congenital cystic malformation of the lung," "congenital cystic lung," "congenital lung cyst," *et cetera*, in the recent literature have been interesting. However, it is difficult to accept, without considerable objection, either the alleged *congenital* origin of the lesions or their *cystic* character.

Congenital intrapulmonary tumors are extremely rare. Virtually all the cases reported under the several titles above presented round air-filled spaces rather than *cysts* (Gr. χυστισ), which by definition are hollow organs, bladders or sacs which contain liquid secretion, parasitic larvae or morbid matter.

It is my opinion that to a minor degree *bronchitis*, and in major degree *bronchopneumonia* are the causative factors in the production of these so-called "cystic" changes in the lung.

The true embryonal or developmental pulmonary cyst presumably is present from intra-uterine life on. It should therefore at birth present a roentgen-opaque shadow, so continuing as long as it contains such secretions as its bronchial epithelial structures may elaborate. When and if it should rupture into an airway (with or without "delayed canalization" of its bronchus or bronchiole), one may assume that there should be an adequate amount of elastic fibers over its periphery to aid in such collapse upon the evacuation of the retained secretions, and that then it might exchange such fluids for air, becoming roentgen transparent. Or, depending upon the rigidity of its wall, it should be collapsible by the counter pressure of the normally aerated lung segments about it.

In a previous contribution with Dirkse on this subject, we mentioned one case of probable true embryonal or developmental pulmonary cyst which I had had the opportunity to observe (with Dr. E. W. Rowe, Lincoln, Nebraska) from time to time. That patient has presented over many years a globular intrathoracic, paramediastinal mass, which periodically has ruptured into a bronchus with resultant sudden expectoration of a quantity of serosanguineous fluid, some signs of shock, some reduction in size of the tumor and a demonstrable fluid level. The latter subsequently disappeared, to be followed by resumption of the former size by the roentgen-opaque mass before the next episode. This conforms to the postulates proposed above as to the true embryonal cyst. Such a case is the *rara avis*.

So far as I can recall, I have yet to see a globular or pear-shaped shadow in a newborn infant's lung fields which would suggest that that child has developmental cystic disease of the lung. The pathologist colleagues whom I have consulted tell me that, in their rather wide experience, they have never seen what they would consider a congenital pulmonary cyst.

The term "congenital" can be used only when the above conditions are unquestionably satisfied.

We must then consider what changes or accidents of life subsequent to birth may produce a cystic type of lesion in the lung.

Disturbances of the upper respiratory tract begin in the early hours or weeks of each human life. The initial inspiratory gasp often does not completely inflate the lungs. The vagaries of temperature and humidity, ventilation, smoke, dust and allergens, and the "common cold" combine in one insult after another to the respiratory

* Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

tract and its adnexa, the paranasal sinuses. I venture that very few persons escape some pneumonic episode before reaching maturity. If the physician will examine closely the history of patients who present some form of "cystic" change in the lung, he will usually discover at least one episode of respiratory infection.

Several observers have commented on the frequency of roentgenographic evidence of peritruncal changes associated with sinusitis, especially in children. A post-nasal drip with recurrent aspiration of the exudate (as has been experimentally proved by others) will undoubtedly induce a certain amount of chronic inflammation of the bronchial mucous membrane, with resultant bronchitis.

McNeil, Macgregor and Alexander have called attention to the relatively high incidence of bronchitis, bronchopneumonia and alveolar (lobar) pneumonia in children from infancy to their "teens." They have shown that, in the child, lobar pneumonia is in reality an alveolar pneumonia, often lacking the complete consolidation of the whole lobe as we commonly think of it in the adult. The inflammatory exudate fills the alveoli to produce a lobular or multilobular consolidation, but accompanied by very little involvement of the interstitial tissue. An initial lymphangitis in the walls of the bronchi may be present, but this passes off as consolidation in the alveoli sets in. The bronchial inflammation when present is no more than a "trivial and superficial catarrh." The alveolar and bronchial walls usually suffer no destruction, and although the consolidation often is neither total nor involves almost all lobules, there is little cause for obstruction of the bronchi or bronchioles. Cough is seldom conspicuous. Interstitial emphysema is very rare, vesicular emphysema not common. Volumetric changes are uncommon for the affected alveoli are filled with the exudate, and the bronchi are not obstructed nor dilated by inflammatory changes in their walls. The lung tends to return to a normal state.

In contrast, bronchopneumonia is initiated or accompanied by a severe bronchitis and bronchiolitis as an essential feature, with alveolar infection as a secondary stage. The bronchioles in the affected area suffer an intense inflammatory process with a copious exudate in the lumen, infiltration of the walls with more or less destruction of the epithelium and a relatively severe peribronchial lymphangitis. The involvement of the perivascular lymphatics not uncommonly spreads into the perivascular connective tissue, and thence into the interstices of the lung with subsequent inflammation in the septa, the pleura and the lung root. This interstitial involvement may be far greater than the alveolar, with subsequent fibrosis. Thrombosis of the blood vessels is associated with this interstitial inflammation, and may induce further necrosis and suppuration of the bronchial walls by the production of infarcts.

These bronchioles, and in the severe forms the bronchi, are the center of a group of more or less consolidated alveoli with interspersed emphysematous alveoli. Emphysematous lobules are more common in the less extensively involved areas where the pneumonic patches are smaller. This may be in part complementary or compensatory to the loss of volume in those lobules whose bronchus or bronchiole is partially obstructed by the inflammatory exudate.

Cough is usually severe, often to the degree of being a conspicuous feature in the clinical picture. This is of importance in what I believe to be the mechanical processes for the production of the various cyst-like changes in the lung. And the nature of the tissue changes described above makes for an imperfect or irregular resolution.

Although in alveolar pneumonia there is virtually no change in the bronchial or bronchiolar walls to obstruct the evacuation of the exudate when resolution occurs, in bronchopneumonia the severe inflammation of the bronchi and bronchioles combine with more or less destruction of the mucous membrane to produce mechanical

obstruction to a uniform resolution and reaeration, accentuated by the forceful and recurrent cough.

In our previous communication, we had suggested that the acquired cyst-like changes, and consequently almost all of those heretofore reported as "cystic pulmonary disease," "congenital cystic lung," *et cetera*, can be classified as:

(a) Cystic bronchiectasis
(b) Chronic interstitial pneumonitis with emphysema
(c) Chronic bullous emphysema
(d) Pulmonary pneumatocele (lobular or alveolar ectasia).

Cystic bronchiectasis represents the most severe damage and the minimal resolution. This is produced by a combination of the destruction and dilatation of the bronchial and bronchiolar walls with more or less cicatricial stenosis of their proximal lumen and an associated distention of their associated pulmonary lobules which remain infected (exudative bronchiectasis), or are diffusely scarred and surrounded by interstitial changes (bronchiectasis sicca). The check-valve of bronchial exudate or cicatrix has persisted long enough for the interstitial and mural scarring of the parenchyma to have been effected in the distended or emphysematous state. (The tension cavity of tuberculosis is somewhat analogous to and usually associated with tuberculous stenosis of the associated bronchus.)

Chronic interstitial pneumonitis with emphysema is commonly the product of a similar but less severe process, in which the destructive changes in the bronchioles are minimal, but the interstitial infection has resulted in chronic scarring while the emphysematous alveoli were fixed in that state. This is more commonly found in association with chronic intractable asthma. But I am of the opinion that its primary cause is a bronchopneumonia. It may be the result of the combined interstitial fibrosis and increased respiratory effort or dyspnea in silicosis.

Chronic bullous emphysema is a more localized lesion probably due to a local bronchitis with or without bronchopneumonia, and sufficient interstitial pneumonitis to fix that segment of lung in a state of vesicular emphysema. In Ayerza's disease the interstitial perivascular inflammation is undoubtedly a considerable factor. The bullous alveoli or lobules may occur next to a scar such as may be formed by surgical drainage of a pulmonary abscess. Under those circumstances one cannot readily determine save by autopsy whether it be due to interstitial scar contraction about a compensatory emphysema associated with the loss of some lung substance, or to torsion of the tributary bronchus due to the change in the lung structure.

The pneumatocele is a localized alveolar or lobular ectasia which may assume alarming proportions and embarrass respiration. It usually appears suddenly in association with a more or less confluent bronchopneumonia. Roentgenographically, within a relatively short period of time an area of apparently confluent pneumonia appears to virtually "shell out," but without excessive expectoration. Occasionally small pneumatoceles are to be seen in or adjacent to a confluent bronchopneumonia. The area of local emphysema (often misinterpreted as excavation) may increase to occupy half of one lung field. The compression of the surrounding lung can be demonstrated bronchographically. This I believe is due to progressive emphysema of an uninfected lobule or group of lobules in association with a bronchopneumonia, because of the check-valve produced by inflammation and exudate in the associated bronchiole or bronchus, and enhanced by the severe spasms of coughing characteristic of that disease.

If the interstitial inflammation is not severe and the check-valve effect in the bronchus resolves, that pneumatocele or "air cyst" will disappear with relief from the dyspnea which usually accompanies it. Sedation of cough and adequate limitation of activity of the patient to his respiratory re-

serve in the early stages should assist an early relief of the patient. When this gross local emphysema resolves, there should be little or no roentgenographic evidence of any scarring and the bronchogram will be essentially normal in appearance.

SUMMARY

(a) "Congenital" or (preferably) "developmental" pulmonary cyst is a very rare lesion, must be roentgenographically evident from birth and histologically proved.

(b) The majority of so-called "cystic diseases of the lung" are acquired.

(c) The most logical causative factors are bronchopneumonia and purulent bronchitis.

(d) A previous classification of the acquired lesions into

(1) Cystic bronchiectasis
(2) Chronic interstitial pneumonitis with emphysema
(3) Chronic bullous emphysema
(4) Pneumatocele (localized lobular ectasia)

has been reiterated, with brief discussion of the mechanics of production.

REFERENCES

1. McNeil, C., Macgregor, A. R., and Alexander, W. A. Studies of pneumonia in childhood: I, II, III, IV and V. *Arch. Dis. Childhood*, 1929, 4, 12–32; 83–94; 111–124; 170–189; 270–282.
2. Miller, William S. The Lung. Charles C Thomas, Springfield, Ill., 1936.
3. Peirce, C. B., and Dirkse, P. R. Pulmonary pneumatocele (localized alveolar or lobular ectasia). *Radiology*, 1937, *28*, 651–667.
4. Sante, L. R. Cystic disease of lung. *Radiology*, 1939, *33*, 152–165.
5. Flemming Møller, P. Congenital thoracic cysts and lung deformities in the roentgen picture. *Acta radiol.*, 1928, *9*, 460–473.

DISCUSSION

Dr. George W. Scupham, Chicago. Dr. Peirce's views on the so-called cystic diseases of the lung are certainly plausible. The fact that Dr. Peirce has been able to classify the cyst-like diseases of the lung as he has and to differentiate these types as to pathogenesis is important. Heretofore it has been impossible to decide upon the manner in which these disorders develop. The theory that all are congenital developmental anomalies has been the consensus, but other observers have considered them as tumors of the type of ovarian cysts, while the theory of the combination of inflammation, infection and mechanical stress in their production has been also previously advanced. This idea is essentially the same as that held to be responsible for the development of bronchiectasis. Whooping cough with the frequently associated bronchopneumonia in infancy seems to provide a destructive inflammatory disease and the mechanical stress resulting from the severe paroxysms of cough, necessary for the production of these abnormalities.

The fact that these cysts vary so much in their pathological structure suggests a diverse causation. That a certain proportion of them are of congenital developmental origin seems certain and with this view Dr. Peirce is in agreement, although he considers them to be extremely rare. As a matter of fact, all of these cyst-like disorders are far from common, although they are being reported and discussed with increasing frequency. Like other disorders with which we have become more familiar, cystic disease of the lung will probably become less frequently confused with tuberculosis, lung abscess, bronchiectasis, pneumothorax, and bronchogenic carcinoma.

In the differential diagnosis of these conditions, roentgen examination has become the most important single factor. The roentgen ray, of course, provides us with information that no other method of examination can, but none the less these findings can be misinterpreted, and therefore the clinical course and symptomatology must be considered.

Like the pathology, the clinical symptoms vary widely from no symptoms at all to the most urgent dyspnea and cyanosis. The symptoms presented apparently are dependent upon the size of the cyst cavity, the pressure relations within and without the structure, rupture and infection. Pressure variations are those resulting mainly from the relationship of the cyst cavity to a bronchus. If the opening is free, the air pressure within is that of the atmosphere, and increased tension does not occur. When such a condition exists as Dr. Peirce described in his discussion of the pneumatocele type with a check-valve effect so that air enters through a bronchus but is expelled with great difficulty, then increased intrathoracic pressure results in crowding of the lung and mediastinal structures.

Urgent dyspnea, cyanosis, paroxysmal cough occur, and if rupture into the pleural cavity occurs, spontaneous pneumothorax with its characteristic clinical picture results. Pleuritic pain, fever, cough with expectoration occur with infection of the cyst cavity. In one case which I had the opportunity of seeing an episode of severe hemoptysis occurred. In childhood the symptoms of increased tension are the usual ones, while in adults those of infection predominate.

Schenck, two or three years ago, reported a group of cases and had collected some 232 cases. Of these the age at which the cyst made its appearance was obtained in 224. According to his report, at birth 27 cysts were demonstrated, those which seemed to be of probable congenital developmental origin. Forty-one were found at the age of one year or less, between one and fifteen years there were 38, and over fifteen years, 118.

It would seem then that of the cases of cystic disease reported up to that time, considerably more than half may have been of the acquired variety inasmuch as they were discovered relatively late.

Vol. 44, No. 6

SPONTANEOUS PNEUMOPERITONEUM IN PERFORATED PEPTIC ULCER

A ROENTGEN-RAY ANALYSIS OF 44 CASES*

By LANGDON T. THAXTER, M.D.
PORTLAND, MAINE

THERE is no better plea for the use of any method that will help in the diagnosis of rupture of gastric and duodenal ulcers than the following quotation from "The Early Diagnosis of the Acute Abdomen" by Cope:[1] "In the case of a perforated ulcer, a delayed diagnosis or a misdiagnosis which leads to temporizing and delay, is equivalent to a death sentence with very little chance of reprieve." Clinical diagnosis is easy and accurate in the majority of cases, but during the past seven years that we have examined by roentgenograms nearly all suspected cases of perforated ulcer, we believe that the additional assurance obtained by the presence or absence of pneumoperitoneum has been a distinct aid in making a diagnosis. Therefore we feel justified in reporting the following series of 44 cases of proved perforated peptic ulcer, all of whom were examined roentgenologically for spontaneous pneumoperitoneum previous to the operation.

Vaughan and Singer,[9] in a review of the literature up to November, 1929, give credit to Popper for first demonstrating spontaneous pneumoperitoneum by the roentgen ray. They, as well as other writers, stress the importance and safety of this method. Singer and Vaughan[8] show the occurrence of pneumoperitoneum in occasional perforations of the "formes frustes" type, and Singer[7] reports 2 cases of pneumoperitoneum discovered during a barium meal examination of the stomach. These reports suggest that, if we extend our roentgenological examinations to include all cases of even vague abdominal pain, occasionally we can diagnose a subacute perforation that has not been suspected. Our opinion is in agreement with that of others, that in all cases it is entirely a safe and sane procedure, and that it does not waste valuable time or inconvenience the patient unduly; for the patient is held in the sitting position on the stretcher for only fifteen seconds, and we do not believe that this increases the dissemination of infection, considering the fact that since the rupture has occurred the patient has changed his position continually.

TECHNIQUE OF EXAMINATION

As a routine we take a posteroanterior film of the diaphragms with the patient in the upright position. This can easily be done without undue inconvenience to the patient by holding him in the sitting position on the stretcher with the film anteriorly. A Lysholm grid may be used but is not necessary. We have found this position more satisfactory than a posteroanterior film with the patient lying on his left side, or a lateral film with the patient recumbent as suggested by Pendergrass and Kirk,[6] inasmuch as the height of the free fluid in the peritoneal cavity is more easily demonstrated, and this we believe to be of some importance, as will be explained later. However, these latter positions are useful if the patient is too sick to sit up.

As a routine, an anteroposterior film with the patient recumbent is also desirable, and the additional information obtained in occasional cases warrants this being done as a routine; for, in one of our cases, a soft tissue mass in the right lower quadrant suggested an appendiceal abscess, which was later proved by operation. Small bowel obstruction, complete or partial, may be shown as it was in a case of volvulus of the small intestine and in a number of cases of paralytic ileus associated with general peritonitis. This film is also useful in excluding other

* From the Department of Roentgenology, Maine General Hospital, Portland, Maine.

causes of acute abdominal pain which may occasionally be confused with perforated ulcer, such as cholelithiasis and urinary calculi.

We do not use roentgenoscopy as a routine, as the time required is greater than in the above method.

DIAGNOSIS

The typical crescentic shadow shown between the right diaphragm and the liver (Fig. 1, *B*) is very characteristic, but should be differentiated from other causes of gas under the right diaphragm as listed by Pendergrass and Kirk,[6] namely, hepatoptosis, subdiaphragmatic abscess containing gas, transposition of the viscera with the stomach on the right side, or a recent abdominal operation. The rare cases of right-sided eventration should also be included in this list.

On the left side the same crescentic shadow is easily visualized, demarcated by the thin shadow of the diaphragm above (*L.D.*) and the superior wall of the fundus of the stomach below (*S.W.*) and should be differentiated from the normal gas bubble in the stomach (*S.G.*) which is not crescentic below but is flat, due to underlying fluid in the stomach (*S.F.*). Gas in the splenic flexure (*S*) also does not show the crescentic line below and therefore may be easily differentiated.

The height of the fluid level indicating the amount of free fluid in the peritoneal cavity is shown at *X* and *Y*. Note that it cuts off the outer inferior limb of the crescentic shadow of the pneumoperitoneum. It is thus necessary to have an air shadow large enough so that its inferior outer border will meet the fluid level, in order to determine whether any free fluid is present, and if so, its height. The free fluid level may be differentiated from the fluid level in the stomach by the fact that the free fluid level is equal in height on both sides, and that it extends to the periphery, whereas the stomach fluid level lies more mesially. Similarly,

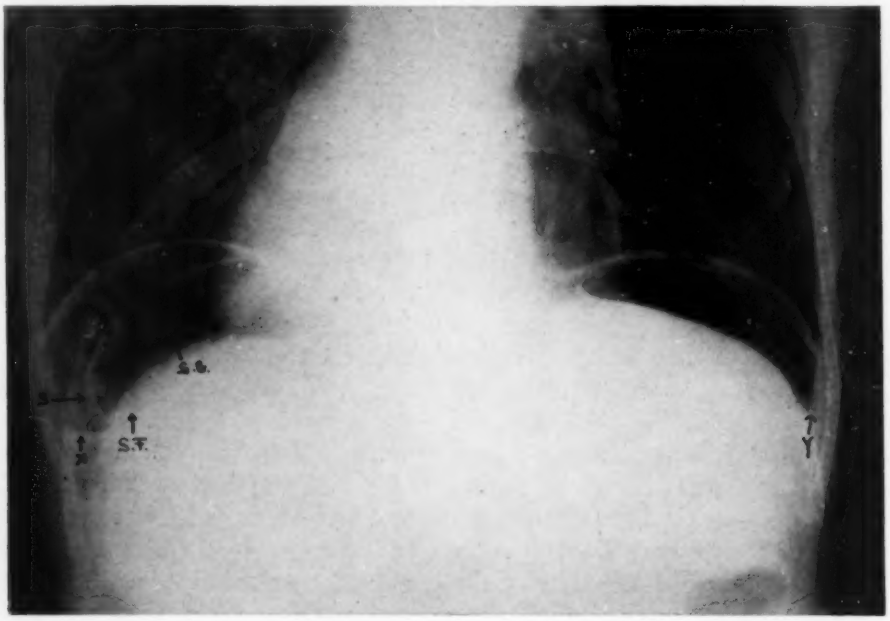


FIG. 1. Male, aged forty-five. Rupture of a gastric ulcer which occurred forty-five minutes before the film was taken. Operation showed free fluid but no peritonitis. Discharged improved from hospital eighteen days later. Note large amount of pneumoperitoneum *A* and *B*, and free abdominal fluid levels *X* and *Y*. *R.D.*, right diaphragm; *L.D.*, left diaphragm; *S.W.*, wall fundus of stomach; *S.G.*, gas bubbles in stomach; *S.F.*, fluid level of stomach contents; *S*, tip of splenic flexure.

it may be differentiated from the fluid level in an air-containing subdiaphragmatic abscess on the right side.

ANALYSIS OF CASES

Age. The average age was 42.1 years. The youngest was twenty-two, and the oldest sixty-six. The greatest number, 12, occurred during the ages thirty to forty.

Sex. There was but one female in the whole series. This is quite astonishing, considering the fact that the ordinary incidence of peptic ulcer in males and females has been estimated at about 4 to 1. Other authors have commented on this point; thus Geier[2] found all cases of perforated ulcer in his clinic to be males, and he quotes a series of 62 cases from a survey by Mayer and Brams, all of whom were males. Walton,[10] in a series of 59 cases, reported 7 females; and Johnson[3] found 3 females in a series of 42 cases. The fact that the average man's work requires more exertion may account for a part of this discrepancy. In our series, 3 cases (all males) gave a history of the sudden acute pain of perforation coming on during heavy lifting.

Previous History of Peptic Ulcer. Thirty-five cases gave a previous history of typical ulcer symptoms; 7 cases denied any previous symptoms up to the time of the acute onset. In 2 cases the history was not obtained.

Physical Signs. All cases showed "board-like" rigidity and generalized tenderness, usually most marked on the right side. There was distention in only 7 cases, all of whom showed general peritonitis at operation.

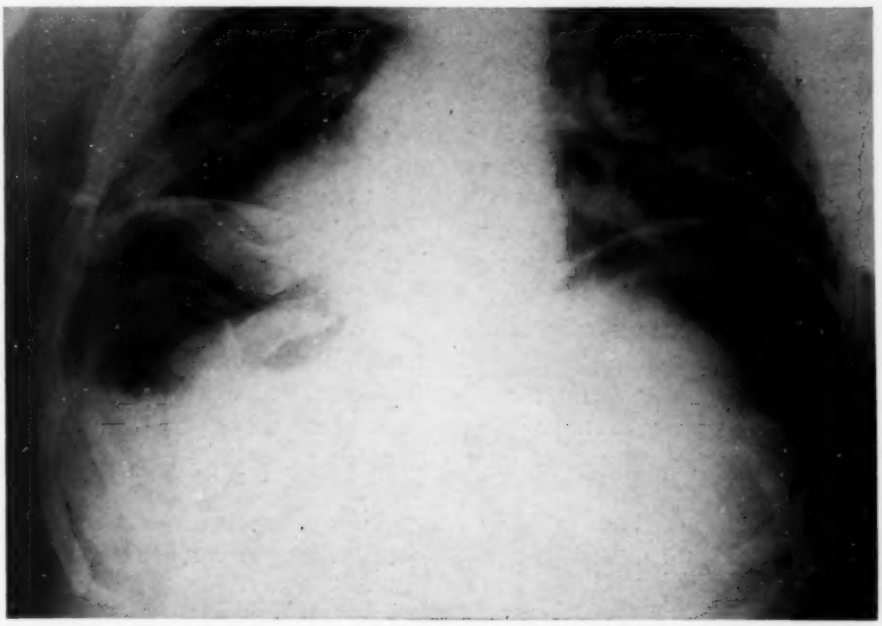


Fig. 2. Male, aged fifty-one. Rupture of gastric ulcer of eighteen hours' duration. Operation showed a large amount of seropurulent fluid mixed with gastric contents. Abdominal organs adherent with dense fibrinous exudate. Note large amount of free gas and free abdominal fluid. Patient died of general peritonitis and bronchopneumonia five days after operation.

Pneumoperitoneum. The typical crescentic shaped area of diminished density beneath either the right or left diaphragm or both (Figs. 1 and 2) was present in 36 cases, or 81.8 per cent. Vaughan and Singer[9] showed 85.7 per cent in 63 cases; Kudlek,[4] 83.3 per cent in 24 cases; Warfield,[11] 43.5 per cent in 35 cases. In our series, the gas was usually shown under both diaphragms,

8 showing it under the right only, and 1 under the left alone. This is perhaps explained by the fact that no attempt was made to localize the gas on the right by having the patient lie on his left side before sitting up.

Moynihan[5] stated that "The amount of gas and of fluid will depend upon the length of time that has elapsed since perforation; if less than six hours have passed there will be little or no gas." This we have not found to be true in our cases, for in 22 cases examined within the first six hours, 16 (72.7 per cent) showed positive evidence of gas. In general, the longer the interval of time since perforation, the larger the amount of gas; but there were many exceptions. Figure 1 shows a large amount of gas in a case which perforated forty-five minutes before the film was taken, and in another case taken ninety-six hours after perforation there was only a trace of gas. Thus the amount of gas is dependent upon various factors:

1. Time elapsed since perforation.
2. Location and size of perforation.
3. Effectiveness of the reaction in walling off the perforation.
4. Amount of air in the stomach at the time of perforation and amount swallowed since.
5. Amount of fluid in the stomach.
6. Positions assumed by patient since perforation.

Free Fluid. The amount of free fluid in the peritoneal cavity is dependent on the amount extravasated through the perforation, and that due to the inflammatory reaction of the peritoneum. The amount of the former depends upon the same factors governing the amount of gas. At operation, all cases showed varying amounts of fluid, but in only 13, or 29.5 per cent, was enough air present under the diaphragm to extend down to the fluid.

However, we wish to stress the importance of the bearing upon the prognosis that the demonstration of a sufficient amount of fluid to show in the roentgenogram has, as the mortality in the cases showing free fluid was 46.1 per cent and in those showing no free fluid only 12.9 per cent. Thus in considering the final prognosis not only should the length of time between the perforation and the operation be taken account of, but also in conjunction with this the amount of free fluid as indicated in the roentgenogram. This was well demonstrated in one of our cases, in which the lesion perforated thirty-one hours before admission, yet the patient survived. A fluid level was barely demonstrable, and at operation the perforation was small and almost closed by the local reaction and there was no general peritonitis. Another case (Fig. 2) of eighteen hours' duration showed the largest amount of gas and the largest fluid level, and at operation had a marked general peritonitis, from which he died five days after the operation. In this case, a large part of the fluid was the result of the peritonitis, as well as that extravasated from the perforation of the stomach.

Mortality. In the cases operated on within the first six hours, the mortality was 9.5 per cent; from six to twelve hours, 10 per cent; after twelve hours, 58.3 per cent, making a general mortality rate for all 44 cases of 23.3 per cent.

SUMMARY

1. An analysis of 44 cases of ruptured peptic ulcer is presented.

2. Spontaneous pneumoperitoneum occurred in 81.5 per cent of these cases, and its importance is discussed.

3. The importance of the amount of abdominal fluid shown by the roentgenograms with reference to prognosis is stated.

REFERENCES

1. Cope, Z. Early Diagnosis of the Acute Abdomen. Oxford Medical Publications, London, 1930, p. 91.
2. Geier, F. A. J. Early diagnosis of perforated peptic ulcer. Am. J. Roentgenol. & Rad. Therapy, 1929, *21*, 465–467.
3. Johnson, S. E. Frequency of air under diaphragm in perforated gastric and duodenal ulcer. *J. Am. M. Ass.*, 1937, *108*, 295.

4. Kudlek, F. Zur Diagnose des durchgebrochenen Magengeschwürs. *Zentralbl. f. Chir.*, 1929, *56*, 1293–1298.
5. Moynihan, B. Abdominal Operations. Fourth edition. Vol. 1. W. B. Saunders Co., Philadelphia, 1926.
6. Pendergrass, E. P., and Kirk, E. Significance of gas under right dome of the diaphragm, with discussion of hepatoptosis. Am. J. Roentgenol. & Rad. Therapy, 1929, *22*, 238–246.
7. Singer, H. A. Barium meal examination of stomach in the presence of unrecognized perforated peptic ulcer. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 191–199.
8. Singer, H. A., and Vaughan, R. T. "Formes frustes" type of perforated peptic ulcer. *Surg., Gynec. & Obst.*, 1930, *50*, 10–16.
9. Vaughan, R. T., and Singer, H. A. Value of radiology in diagnosis of perforated peptic ulcer. *Surg., Gynec. & Obst.*, 1929, *49*, 593–599.
10. Walton, A. J. Nelson's Loose-Leaf Living Surgery. Thomas Nelson & Sons, New York, 1928, Vol. v, Chap. ii, p. 47.
11. Warfield, C. H. Spontaneous pneumoperitoneum in ruptured peptic ulcer. *Radiology*, 1930, *14*, 591–593.

THE CORRELATION OF THE ROENTGEN AND BLOOD EXAMINATIONS IN MULTIPLE MYELOMA

By W. JAMES MARQUIS, M.D.
NEWARK, NEW JERSEY

IN THE practice of general roentgenology one encounters relatively few cases of multiple myeloma. If the disease is well advanced and presents some suggestive clinical symptoms, the roentgen findings will probably be characteristic of the disease, and no difficulty will be experienced in making a correct diagnosis. In the early stages of the disease, the symptoms are usually so indefinite that the clinician does not suspect the true nature of the disease. The patient may be referred to the roentgenologist for a varied list of reasons running from a general checkup on chest or sinuses to a study of a soft tissue tumor in some part of the body. It is probably the experience of the average general roentgenologist either to make a diagnosis from the fairly typical roentgen appearance, which is a surprise to the clinician, or to be in turn puzzled by the unusual and bizarre roentgen findings. He will then be inclined to make a diagnosis similar to that of his last case which presented unusual and rare roentgen findings. The cases in this article are presented because they have occurred in the practice of a general roentgenologist and each case presented a problem in diagnosis. One case came to autopsy, two have had biopsy examinations, and the fourth had typical blood findings and a fairly characteristic roentgen picture.

It is not intended to make this paper an exhaustive review of this disease. The recent book "Tumors of Bone" by Geschickter and Copeland[11] contains a very excellent chapter on the subject in which they discuss in detail the difficulties in diagnosis. The summary of the chapter, in part, is as follows:

> Multiple myeloma is a rare form of tumor causing death and developing in many foci in the red bone marrow of adults. The ribs, spine, pelvis and upper ends of the femora are most frequently affected and the patients are generally in the sixth decade of life. Clinically, in addition to the rheumatic pains, there are skeletal deformities, leading to pulmonary changes with emphysema and neurological manifestations such as radiculitis and paraplegia. A nephrosis with non-protein nitrogen retention and a low blood pressure associated with an albuminous substance in the urine, known as Bence-Jones bodies, is present in from 65 per cent to 70 per cent of the cases. The plasma proteins may be markedly increased. The tumors in multiple myeloma are bone destructive and appear in the x-ray as multiple punched out areas, varying in size from that of a pea to that of an orange. The tumors produce pathologic fractures in 62 per cent of the cases, a rib being the most frequent bone thus involved. Microscopically, the tumors are composed of a plasma-like cell with an eccentric nucleus containing a spoke-like arrangement of chromatin.

Since the publication of Geschickter and Copeland's book there have been many additional articles pertaining to some phase of the diagnosis of this disease.

Ehrlich[8] cites 7 cases and discusses the difficulty in making a diagnosis in some cases even after microscopic sections are studied.

Rosselet and Decker[18] report a case of plasmocytic myeloma with only one disease focus. The site of the lesion was in the bodies of the fifth to seventh cervical vertebrae. There was also an unusually good response to roentgen therapy in this case.

Palugyay[16] discusses the difficulties of making a definite diagnosis from the roentgen examination and states that four conditions are likely to be confusing: (1) osteomalacia; (2) von Recklinghausen's osteitis fibrosa cystica generalisata; (3) sarcomatosis; (4) metastatic carcinoma of bone marrow.

Bianchini[3] describes a case in which the correct diagnosis was made only after the

patient had been subjected to one operation without relief, and after a swelling appeared in the median third of the right femur. A spontaneous fracture occurred a few days later. A roentgen examination and the presence of Bence-Jones bodies in the urine led to the diagnosis. He also lists chloroma and Paget's disease as conditions which are likely to be confusing in making a diagnosis.

Pazzi[17] also describes a case in which the correct diagnosis was reached only after examination of the urinary tract which was made as a routine measure.

Canigiani[5] states that the far-reaching similarities of the roentgen appearance of the two diseases (disseminated osteolytic carcinomatosis metastases and multiple myeloma) makes differential diagnosis unusually difficult; sometimes almost impossible. At times he believes differentiation from multiple osteomyelitis, tuberculosis and syphilis is not easy—and only possible with great experience.

Mach and Mach[14] cite the case of a patient who presented clinical and roentgenologic signs of a generalized carcinoma of the skeleton but in which the autopsy revealed a multiple myeloma of plasma cells.

Jenkinson and Foley[12] describe a case which was observed for over two years, and they were never able definitely to classify the bone lesions which developed from time to time. They point out that it is impossible to classify tumors as to their histology from roentgen findings and it is not necessary to try. Whether the bone lesion is malignant or benign is all that can be expected and even not this in all cases. Their case also demonstrates the difficulty of classifying these bone lesions even from the microscopical sections.

Meyerding[15] gives a very good description of the different points that can be noted in making a differential diagnosis.

Altschul[1] describes a case of sporotrichosis, with roentgen findings similar to those of multiple myeloma.

It is readily apparent from this short review of the literature that any help in making a diagnosis, even after the lesions are demonstrable in roentgenograms of the bone, would be greatly appreciated. An article by Foord and Randall[10] describes the presence of autohemagglutination, renal insufficiency and hyperproteinemia in cases of multiple myeloma. Feller and Fowler[9] in a recent article present a comprehensive review of the blood findings, citing 52 cases of multiple myeloma with hyperproteinemia which have been reported in the literature, most of them since 1928. In a study they made of 10 patients, 3 had a hyperproteinemia (total protein over 9 per cent). They state that in the cases with a distinct hyperproteinemia, the albumin fraction was either normal or slightly below and the increase in the total protein was due chiefly to globulin. These findings were present in 2 of our cases and proved of definite value in making a differential diagnosis.

REPORT OF CASES

Case 1. This patient was a white male, aged fifty-one. He had always been a healthy man working out of doors. Six months ago he began having pains in his back and had to stop work. He had no chills or fever. Several physicians

Fig. 1. Case 1. Roentgenogram made on January 8, 1931. At this time there is evidence of a lesion involving the body of the twelfth dorsal vertebra as shown by areas of decreased density and a slight narrowing of the anterior portion of the body.

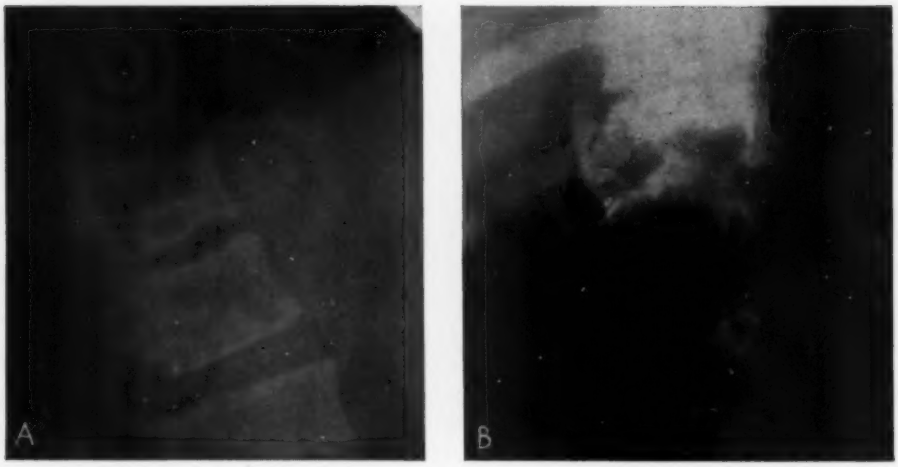


FIG. 2, *A* and *B*. Case 1. Roentgenograms made on September 9, 1932. There is now evidence of a greater degree of destruction of the body of the twelfth dorsal vertebra.

examined him and concluded he had arthritis. His teeth were removed and a cast applied to his back. The pain continued and he entered the Homeopathic Hospital on February 13, 1931.

A roentgenogram of the spine at this time showed evidence of a destructive lesion involving the body of the twelfth dorsal vertebra (Fig. 1).

FIG. 3. Case 1. Roentgenogram made February 2, 1933. This was after a series of deep roentgen treatments and it is noted that, although there is marked wedging of the body of the twelfth dorsal vertebra, there is good density of the bone.

The lesion was thought to be caries of the spine. On March 3, 1931, exploratory operation was performed and the body of the twelfth dorsal and spinal end of the twelfth rib were found to be softened. Dissection revealed purulent material and friable tissue. A specimen was sent to the laboratory. A diagnosis of lymphosarcoma was first made but later changed to myeloma of the plasma cell type. The patient improved and left the hospital on March 16, 1931.

On June 3, 1931, he was re-admitted to the hospital because of pain in his back. He was discharged June 12, 1931.

The patient was admitted to the hospital again on September 13, 1931. A roentgenogram

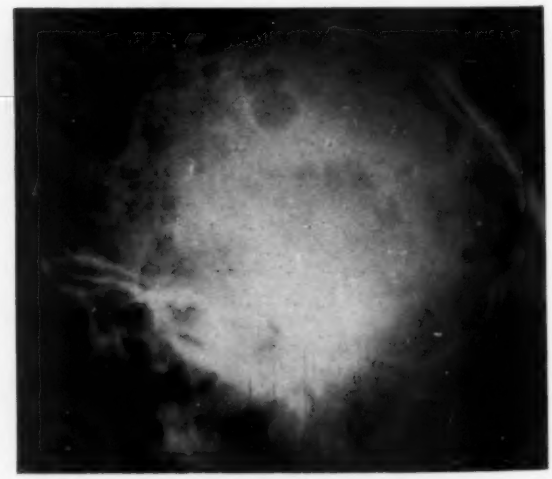


FIG. 4. Case 1. Roentgenogram of the head made on October 13, 1934. This was only a short time before death and there are now the typical punched-out appearing areas of decreased density, typical of multiple myeloma.

Fig. 5. Case 11. Roentgenogram of the right humerus made July 7, 1935, showing the fracture of the lower end of the bone, said to have occurred while in the surf as a result of a wave striking the patient. One can note a mottling in the upper end of the shaft.

of the spine at that time showed increased destruction of the body of the twelfth dorsal (Fig. 2, *A* and *B*).

He was referred to the Metcalf Foundation for roentgen therapy. Through the courtesy of

Fig. 6. Case 11. Roentgenogram of the head made July 17, 1935. Note that the areas of decreased density are so numerous they have become confluent. This gives an appearance which is not the usual finding in multiple myeloma.

Dr. Seward roentgenograms were loaned to me, made February 2, 1933, which showed moderate changes in the appearance of the vertebra as compared to the examination of September 1932 (Fig. 3). However, by October, 1934, the typical bone lesions of multiple myeloma were present throughout the skeletal framework (Fig. 4).

Fig. 7. Case 11. Roentgenogram of the left femur made January 18, 1936. Note the fine mottling in the upper end of the femur and the large cystic appearance in the middle part of the shaft. There was also marked decalcification of the vertebrae.

FIG. 8. Case III. Roentgenogram of the head made January 10, 1936, showing a fine mottling, particularly over the frontal areas.

The laboratory findings were not significant except that on April 16, 1931, the alcohol precipitation method was positive for Bence-Jones bodies in the urine. The heat test was negative. Hemoglobin was 87 per cent; red blood cells, 4,500,000; white blood cells, 15,900. On February 14, 1931, the urea nitrogen was 20.8 mg. per 100 cc. On September 13, 1931, the Bence-Jones test was negative.

CASE II. The patient was a female, white, married, aged fifty-five. She was sea bathing and the force of the waves broke her right arm above the elbow (Fig. 5).

The fracture was reduced and she was admitted to the Presbyterian Hospital on July 15, 1935, for study because of the appearance of the humerus.

The patient had always been in good health except for severe attacks of pleurisy the past winter. She had also lost 34 pounds during the last year.

A study of the blood calcium showed the following:

7-16-35—Calcium, 11.7 mg. per 100 cc. serum.
7-19-35—Calcium, 7.2 mg. per 100 cc. serum.
Phosphorus, 4.1 mg. per 100cc. serum.
Phosphatase, 5.6 units per 100 cc. serum.

A roentgenogram of the head, femur, and spine showed decreased density and mottling (Figs. 6 and 7 *A* and *B*).

On July 23, 1935, the parathyroids were explored and found to be small but one was removed in the hope that some relief from the pain would result. Examination of the blood serum one week after operation showed the following:

Calcium, 10.0 mg. per 100 cc. serum.
Phosphorus, 3.8 mg. per 100 cc. serum.

Following the removal of a parathyroid, there was symptomatic improvement for a few months. However, she was re-admitted to the hospital on January 15, 1936, with inability to walk and extreme pain in the back. There was not much change in the appearance of roentgenograms of the bones. The patient soon died and autopsy showed multiple myeloma.

Caylor and Nickel[6] report a case in which the spine and ribs revealed an osteoporosis with numerous round to oval shaped rarefactions. There were similar findings in the head, long bones, pelvis and hands. There was no albuminuria, blood calcium was high, negative calcium balance and the blood phosphorus was normal. Biopsy of the twelfth rib revealed a multiple myeloma of the plasma-cell type.

Jores[13] also discusses the question of differentiating between multiple myeloma and osteitis fibrosa generalisata with particular reference to calcium metabolism. He concludes that in osteitis fibrosa generalisata changes in the calcium metabolism are not present only in this disease and thereby

FIG. 9. Case III. Roentgenogram made on January 13, 1936, showing the marked decalcification of the lower dorsal and upper lumbar vertebrae.

lose in differential diagnostic value, at least in the demarcation from myeloma and osteoclastic carcinoma. He also states that generally speaking, the demarcation from these diseases offers no difficulties since in most cases the roentgen picture with its cystic transparencies characteristic of osteitis fibrosa will give the differentiation. Feller and Fowler[9] found that in 5 of their 10 cases the serum calcium was 12 per cent or over and that in 3 of these 5 cases there was an associated increase in the inorganic phosphorus. They conclude that this may be of value in differentiating multiple myeloma or other malignancies involving the skeletal system from hyperparathyroidism in which there is, as a rule, an increased blood calcium but a lowered phosphorus content.

Case III. The patient, a white woman, married, aged fifty, was admitted to the Homeopathic Hospital on January 6, 1936, for observation. She was thought to be a neurasthenic because of the vague complaints and yet at times she appeared to be suffering from extreme pain, mostly in the neck and chest. This had been growing worse for two years. As a routine measure, roentgenograms were made of the sinuses and chest (Fig. 8). Because of the peculiar mottling of the head, additional roentgenograms of other bones, including the spine, were made (Fig. 9). The decreased density of the bodies of the vertebrae and the mottling led to a diagnosis of hyperparathyroidism.

Fig. 10. Case IV. Roentgenogram of the left ilium made on October 11, 1937. This shows the large area of bone destruction without any proliferative reaction. Over the posterior aspect of the body corresponding to this area, there was a soft tissue tumor.

Fig. 11. Case IV. Roentgenogram of the head made October 8, 1937. There are only a few areas of decreased density suggestive of the small punched-out appearance of multiple myeloma.

Study of the blood showed the presence of marked autohemagglutination and a high proteinemia.

On January 14, 1936, the hemoglobin was 32 per cent; red blood cells, 2,750,000; white blood cells, 6,800. Bence-Jones protein negative. There was spontaneous agglutination of the red blood cells.

Urea nitrogen	43.4	mg. per 100 cc.
Total protein	19.98	per cent
Albumin	1.97	
Fibrinogen	2.5	
Globulin	15.5	
Calcium	9.8	mg. per 100 cc. serum.
Phosphorus	3.1	mg. per 100 cc. serum.

The patient died several months later and an autopsy was not obtained. However, because of the blood findings and the fact that the roentgen findings could be of the diffuse type of multiple myeloma described by Blaine,[4] it was thought probably to be myeloma.

Case IV. The patient was a male, white, married, aged fifty-three. He was admitted to the Homeopathic Hospital on October 8, 1937, complaining of pain in the left hip of one year's

duration. The pain had become so severe the patient could not turn. There was nausea and vomiting and a loss of 30 pounds during the last six months. There was a tumor mass projecting posteriorly near the junction of the crest of the left ilium with the spine.

A roentgenogram of this area showed a large destructive lesion without any bone reaction (Fig. 10). There were also some small areas of decreased density in the skull (Fig. 11). A tentative diagnosis of a malignant lesion, probably multiple myeloma, was made. This was supported by the laboratory findings of a high proteinemia and marked autohemagglutination.

FIG. 12. Case IV. Roentgenogram made of the left ilium on February 3, 1938. This shows that the crest of the ilium has filled in considerably, but the lesion seems to be extending downwards. The soft tissue tumor disappeared as the result of the roentgen treatments.

The laboratory findings were as follows: hemoglobin, 30 per cent; red blood cells, 2,200,000; white blood cells, 8,800. Calcium, 10.8 mg. per 100 cc. of serum; phosphorus, 3.36 mg. per 100 cc. of serum; phosphatase, 2.80 units per 100 cc. of serum. Sedimentation 123 mm. in one hour (corrected). There was spontaneous agglutination of the red blood cells. Total protein was 12.1 per cent; albumin, 0.6 per cent; globulin, 8.2 per cent; fibrinogen, 3.6 per cent.

The patient submitted to exploratory operation and some tissue was removed for microscopic study. This showed the lesion to be myeloma. The pathologist, Dr. Fendrick, reported the biopsy as follows: "The cells do not resemble characteristic plasma cells, but appear more like early progenitors of the granular series, in that respect resembling a myelogenous leukemia. The picture, however, is quite definitely that of a new growth arising from bone marrow, type myeloma."

The patient was given a moderate course of roentgen treatments and symptomatic improvement has occurred. There has been bone repair, particularly along the crest of the ilium (Fig. 12).

This case is similar to that recently reported by Bérard, Ponthus and Martin[2] in that there was involvement of an iliac crest with a soft tissue mass. In their case the right iliac bone was involved and the mass was in the right buttock. There was also involvement of the left tenth rib. Histologically the lesion showed plasmocytes.

DISCUSSION

These cases illustrate some of the difficulties in making a diagnosis of multiple myeloma. In only one, Case II, were the lesions disseminated throughout the bones at the time of the first examination; and in this case, the lesions were of unequal size, shape, and distribution. The calcium and phosphorus content of the blood and the absence of Bence-Jones bodies in the urine were suggestive of hyperparathyroid disease.

Two patients, Cases I and IV, presented single lesions with no characteristic roentgen findings. In the first case, the microscopical findings at first were not conclusive and it was only by subsequent developments that a definite diagnosis was made.

In one patient the roentgen findings were found in routine examination of the sinuses and were not typical of multiple myeloma as usually described. In this case and in Case IV the blood findings of autohemagglutination and high proteinemia were of definite value in making a diagnosis.

The only form of treatment used was roentgen therapy. There was some alleviation of symptoms in Case I and in Case IV,

the latter being under treatment at the present time.

Coley[7] deplores the present pessimistic attitude toward the treatment of multiple myeloma. He states that in a number of cases the disease has been held in check for a considerable period of time by the toxins of erysipelas and *Bacillus prodigiosus* alone, irradiation alone, or by a combination of both agents. Certainly in 2 of these cases, I and IV, irradiation has proved to be of definite value.

CONCLUSIONS

1. The roentgen examination in multiple myeloma may reveal (*a*) only a single lesion characterized by a destructive lesion without any evidences of repair or invasion of soft tissues; (*b*) multiple small punched out areas of decreased density resembling the typical roentgen lesion of multiple myeloma or the areas may be small with a diffuse loss of density, usually in the spine.

2. A soft tissue tumor may be the first objective finding as to the site of the lesion.

3. A study of the blood chemistry may give information which, together with the roentgen examination, will establish a diagnosis.

REFERENCES

1. Altschul, W. Similarity of roentgen findings in multiple myeloma and in sporotrichosis. Am. J. Roentgenol. & Rad. Therapy, 1926, *15*, 224–226.
2. Bérard, L., Ponthus, P., and Martin, J. F. Roentgen diagnosis of myeloma. *Bull. et mém. Soc. de radiol. méd. de France*, 1937, *25*, 406–409.
3. Bianchini, A. Value of roentgenology in diagnosis of multiple myeloma of the bones. *Radiol. med.*, 1925, *12*, 140–158.
4. Blaine, E. S. Myelomatosis; with special reference to roentgenological features. *Radiol. Rev.*, 1927, *4*, 6–9.
5. Canigiani, T. Differential diagnosis of disseminated osteolytic carcinomatous metastases and multiple myeloma. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1935, *52*, 386–400.
6. Caylor, H. D., and Nickel, A. C. Multiple myeloma simulating hyperparathyroidism. *Ann. Surg.*, 1933, *97*, 823–827.
7. Coley, W. B. Multiple myeloma. *Tr. Am. Surg. Ass.*, 1930, *48*, 489–514.
8. Ehrlich, D. E. Multiple myeloma. *Radiology*, 1934, *23*, 418–428.
9. Feller, A. E., and Fowler, W. M. Hyperproteinemia in multiple myeloma. *J. Lab. & Clin. Med.*, 1938, *23*, 369–378.
10. Foord, A. G., and Randall, Lillian. Hyperproteinemia, autohemagglutination and renal insufficiency in multiple myeloma. *Am. J. Clin. Path.*, 1935, *5*, 532–547.
11. Geschickter, C. F., and Copeland, M. M. Tumors of Bone. American Journal of Cancer, New York, 1931.
12. Jenkinson, E. L., and Foley, J. M., Interesting study of bone lesions which proved to be myelomata. *Med. Clin. North America*, 1934, *17*, 1537–1552.
13. Jores, A. Differential diagnosis of multiple myeloma and of osteitis fibrosa generalisata with special consideration of carcinoma metastases. *Klin Wchnschr.*, 1931, *10*, 2352–2354.
14. Mach, R. S., and Mach, E. Multiple myeloma simulating neoplastic metastases of the bones. *Bull. et mém. Soc. méd. d. hôp. de Paris*, 1935, *51*, 876–880.
15. Meyerding, H. W. Multiple myeloma. *Radiology*, 1925, *5*, 132–146.
16. Palugyay, J. Roentgen diagnosis of multiple myeloma. *Röntgenpraxis*, 1929, *1*, 447–453.
17. Pazzi, E. Another case of multiple myeloma of the bones revealed by roentgen examination. *Radiol. med.*, 1926, *13*, 799–803.
18. Rosselet, A., and Decker, P. Case of plasmocytic myeloma with only one disease focus. *Strahlentherapie*, 1936, *56*, 337–340.

TREATMENT OF ADVANCED AND RECURRENT CARCINOMA OF THE BREAST*

By WILLIS S. PECK, M.D.,† HENRY K. RANSOM, M.D., *and* FRED J. HODGES, M.D.
ANN ARBOR, MICHIGAN

THE importance of the early recognition of cancer and its appropriate treatment by surgery and irradiation has been extensively stressed, while relatively little attention has been devoted to the more discouraging subject of prolonging the lives and alleviating the suffering of patients with incurable cancer. A great many women afflicted with mammary carcinoma fail to seek medical advice until the disease has progressed beyond the curable stage. Among those who are treated promptly following the discovery of the primary lesion, the subsequent development of local recurrences and distant metastases is not at all uncommon. These two groups, which constitute a majority of all breast carcinoma patients, present an important problem for the radiologist because to a very large extent irradiation is the only feasible method of palliation.

A review of the case records of all breast carcinoma patients admitted to the University Hospital during the period 1931 to 1938 serves to emphasize the importance of providing care in advanced or recurrent cases. After the exclusion of all patients whose records failed to contain reliable proof of the existence of breast carcinoma, there remained 920 cases suitable for study. These have been classified according to the extent of the neoplasm. The clinical grouping employed is similar in many respects to the classifications which have been advocated by Portmann[6] and Pfahler[5] (Table 1).

TABLE I

CLINICAL CLASSIFICATION OF BREAST CARCINOMATA (EXTENT OF LESION)

I.	Neoplasm localized to mammary gland. No skin involvement. Operable.
II.	Neoplasm confined to breast and axilla. No fixation of axillary contents. Operable.
III.	Extensive neoplastic invasion of skin, fixation of axillary contents or remote metastases. Inoperable.

When the 920 consecutive cases of breast carcinoma under consideration are arranged according to this classification (Fig. 1), it is necessary to take into consideration the fact that some of these patients had already been subjected to treatment of one sort or another before admission to this institution. Of the 514 patients who had received no treatment of any sort, 163 (31.7 per cent of untreated patients, 17.7 per cent of the entire group) had already reached the stage of inoperability.

One hundred and sixty-two patients had been treated prior to admission by some method other than radical surgery. Of this group, 86 (53 per cent–9.3 per cent of the total group) could no longer be considered operable.

The breast cancers of 244 patients had been removed by radical mastectomy at some time prior to their admission to this institution. Of these, 63 showed no demonstrable evidence of recurrence or distant metastases, while 181 (74.1 per cent–19.7 per cent of the entire group) presented evidences of local recurrence and distant metastases justifying their classification as inoperable.

In all, at the time of admission there were among the 920 consecutive patients with breast carcinoma 430, or 46.6 per cent, to whom nothing more than palliative treatment could be offered. Unfortunately this does not complete the list of patients with advanced breast carcinoma observed during the period under consideration, for a

* From the Departments of Roentgenology and Surgery, University of Michigan Medical School and University Hospital, Ann Arbor. Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.
† Now in Toledo, Ohio.

number classified as "operable" when first examined returned at a later date with recurrences or metastases following initial treatment in this hospital. Figure 1 shows this transfer of case material from the operable to the inoperable classification. Judged upon the basis of the actual experience here described, it is to be expected that, when first contacted or later in the course of their disease, over one-half (56.1 per cent) of all patients with breast carcinoma who present themselves for treatment must be considered as inoperable cases. Lewis and Rienhoff[4] discovered that local recurrences developed in 31.9 per cent of the patients operated upon between 1889 and 1894 by Halsted. Assuming that some such ratio of recurrence will be experienced with the group here under consideration, still further additions to the inoperable classification are to be expected at some time in the future. Faced with this state of affairs, physicians engaged in the care of patients afflicted with mammary carcinoma must be prepared to advise and provide methods of treatment which offer reasonably effective palliation, as well as radical procedures designed to completely eradicate the disease.

In dealing with a large group of patients with breast carcinoma in late stages of advancement, circumstances frequently demand that decision be made as to whether surgery, irradiation, or mere palliative medication is to be the procedure of choice. An attempt has been made, therefore, to list representative clinical situations describing for each the most satisfactory method of treatment. The opinions offered here represent conclusions reached in Neoplasm Conference based upon the clinical experience provided by the patient group under consideration. As a basis for discussion of the various phases of advanced cancer of the breast, the commonly encoun-

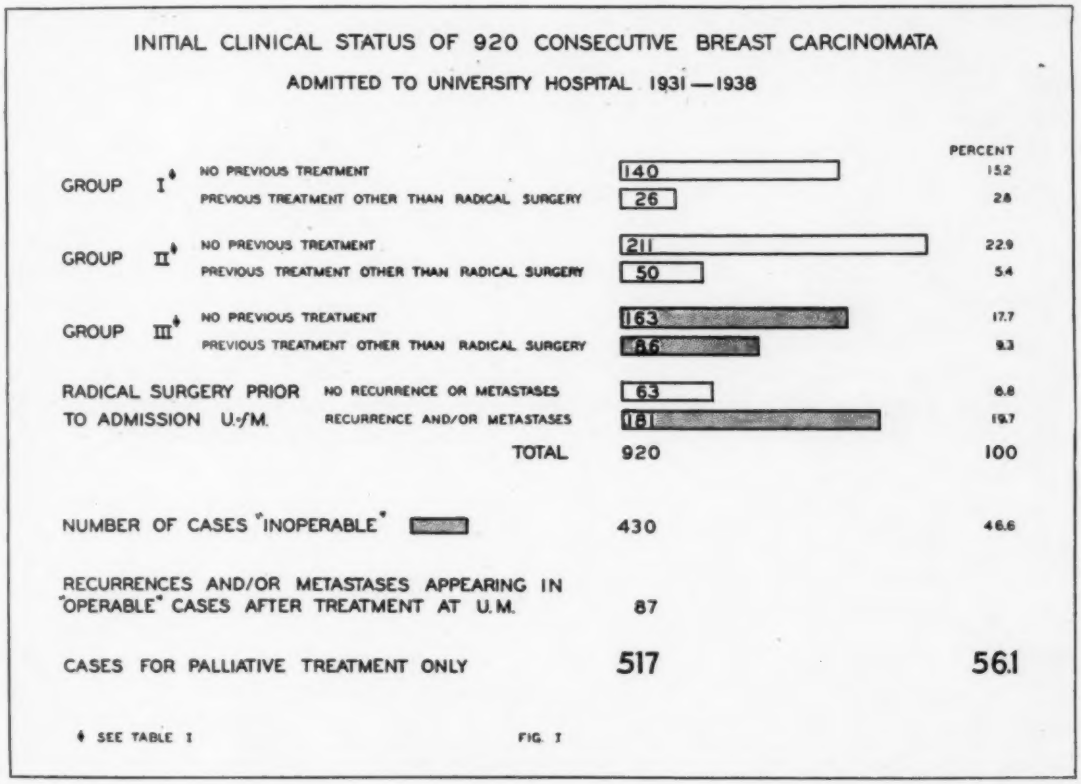

INITIAL CLINICAL STATUS OF 920 CONSECUTIVE BREAST CARCINOMATA
ADMITTED TO UNIVERSITY HOSPITAL 1931—1938
PERCENT
GROUP I♦ NO PREVIOUS TREATMENT 140 15.2
PREVIOUS TREATMENT OTHER THAN RADICAL SURGERY 26 2.8
GROUP II♦ NO PREVIOUS TREATMENT 211 22.9
PREVIOUS TREATMENT OTHER THAN RADICAL SURGERY 50 5.4
GROUP III♦ NO PREVIOUS TREATMENT 163 17.7
PREVIOUS TREATMENT OTHER THAN RADICAL SURGERY 86 9.3
RADICAL SURGERY PRIOR TO ADMISSION U.of M. NO RECURRENCE OR METASTASES 63 6.8
RECURRENCE AND/OR METASTASES 181 19.7
TOTAL 920 100
NUMBER OF CASES "INOPERABLE" 430 46.6
RECURRENCES AND/OR METASTASES APPEARING IN "OPERABLE" CASES AFTER TREATMENT AT U.M. 87
CASES FOR PALLIATIVE TREATMENT ONLY 517 56.1
♦ SEE TABLE 1
FIG. 1

Fig. 1

FIG. 2. Right breast shows masses, a contracted breast, infiltration of the skin and "pig skin" appearance common in advanced local breast cancer.

tered situations have been classified (Table II).

TABLE II

COMMON CLINICAL EXAMPLES OF ADVANCED BREAST CARCINOMA

I. Local lesions (untreated).
   a. Breast contains multiple carcinomatous masses (inoperable).
   b. "Inflammatory type" of carcinoma.
   c. Slowly growing carcinoma with contraction of breast.
   d. Ulcerating carcinoma.
   e. Bilateral carcinomatous involvement of the breasts.
II. Axillary and supraclavicular metastases (untreated).
   a. Large but movable axillary metastases.
   b. Fixed axillary metastases.
   c. Supraclavicular metastases.
III. Remote metastases.
   a. Metastatic lesions in bone.
   b. Pulmonary, liver and other remote metastases.
IV. Local recurrences.
   a. Postoperative.
      1. Multiple subcutaneous nodules.
      2. Recurrences in the scar.
      3. "Inflammatory type" of recurrence in the chest wall.
   b. Post-irradiation.

In any large series of carcinomata of the breast there are certain cases in which the nature of the local lesion contraindicates immediate radical surgical intervention. Thus, fixation of the tumor to the thoracic wall, widespread skin involvement, high degree of malignancy, extensive ulceration with infection, and associated pregnancy are common examples. The responsibility for the immediate treatment of such cases should be placed in the hands of the radiologist.

One of the most common examples of an inoperable local lesion is the enlarged breast containing multiple, poorly defined, firm masses which seem to coalesce. Usually the overlying skin is extensively involved producing edema and the characteristic "pig-skin" appearance so frequently associated with advanced breast cancer. Often the tumor is adherent to the chest wall (Fig. 2). Complete eradication is not possible by immediate surgical operation, and incomplete removal frequently does more harm than good.

Such lesions are best treated primarily with heavy irradiation of the breast and axilla. Roentgen radiation, in divided doses, delivering at least 1,800 to 2,400 r to each of two breast portals and two or more axillary portals, represents the range of dosage now used in this institution for such cases.* Interstitial radium has not been used in a sufficiently large number of cases to warrant any definite conclusions. Mastectomy is considered six to eight weeks after cessation of the irradiation.

Remote metastases, adherent primary tumor, or extensive skin metastases constitute contraindications to radical mastectomy; advanced age or associated constitutional disease may often render the radical operation inadvisable. If only the complication of fixed axillary metastases exists, a simple mastectomy is frequently advised. The operation is easily performed under local anesthesia and every effort is made to secure a primary closure of the wound. Such measures are, of course, not considered curative but are employed to remove residual carcinoma which may at a later date produce distressing complications. The importance of removal of the breast is supported

* Half-value layer—1.0 mm. Cu, focal skin distance—50 cm., portals 100–400 sq. cm. as needed to completely irradiate the breast and axilla with convergent beams.

by the fact that apparently viable cancer cells are frequently demonstrated in breasts removed following irradiation. Occasionally a borderline case, which at first seems inoperable, is converted by irradiation into one technically suitable for radical mastectomy.

The inflammatory type of carcinoma or, as it is sometimes called, "cancerous mastitis" is relatively infrequent. While most often associated with pregnancy or lactation, the disease may occur in the non-pregnant state.[7] The breast involved with this type of carcinoma seldom presents any localized tumor mass. Unlike the type of breast tumor previously described, the entire breast becomes uniformly enlarged and firm, with considerable edema of the skin. Frequently blocking of lymphatic channels by masses of carcinoma produces an appearance simulating an infectious process

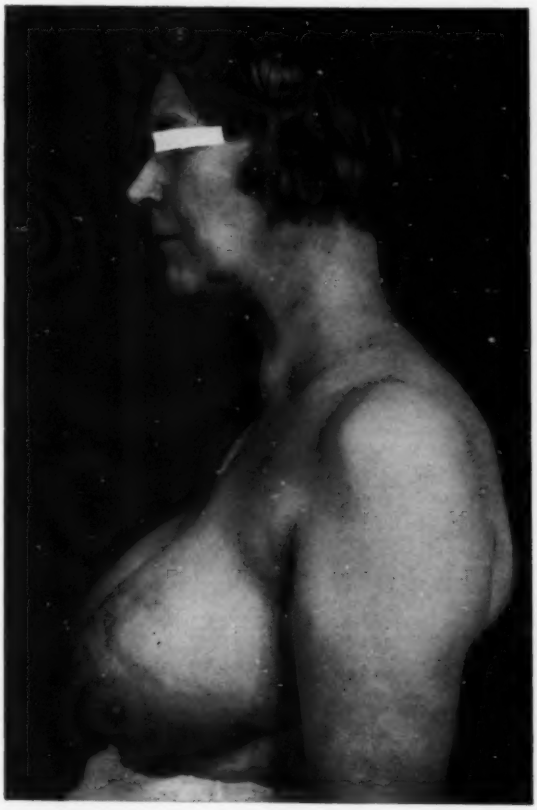


Fig. 3. Inflammatory type of breast cancer or cancerous mastitis.

Fig. 4. Slowly growing cancer in atrophied breast of an elderly woman showing contraction of breast and retraction of the nipple.

(Fig. 3). The neighboring skin is infiltrated at an early date and the lesion soon metastasizes widely, thus giving a very poor prognosis. These inflammatory signs may occasionally be superimposed upon a preexisting carcinoma of the usual type.

The view is now generally accepted that surgery has little to offer in dealing with such lesions. It is our belief that in the management of such a case, the patient's best chance for relief is through intensive irradiation. When using external irradiation in such cases, particular care should be taken to include even more than the usual amount of apparently normal skin in the irradiation field, because of the invisible lymphatic extensions.

The slowly growing carcinoma which tends to produce contraction of the breast usually occurs in patients who have passed the menopause. In this series, the average age of all patients with breast carcinoma was approximately fifty years. There were 22 patients among the 920 who had had evidence of a primary local lesion without axillary or remote metastases for three to ten years before they were treated. Only 6 (27 per cent) of these patients were less

FIG. 5. Type of ulceration in advanced breast cancer.

than fifty years of age while 6 others were over seventy years. In these cases there is usually found a discrete tumor mass which is readily palpable in the atrophic breast. The mass is stony hard, has an ill-defined border and may be fixed to the underlying tissues. Ulceration is very late and extensions tend to occur slowly, particularly if the growth has a scirrhous character (Fig. 4). While the carcinoma may have been present for many months and may appear to involve a relatively large portion of the atrophied breast, it should not be classed in the incurable group.

Of the 22 patients in this group, 12 were operated upon and 10 of these also received postoperative irradiation. One of these patients who was thirty-five years of age developed remote metastases twenty-nine months after operation and died at forty-six months. None of the other 11 patients have developed recurrent or metastatic cancer during the ensuing one to seven years. Among the 10 unoperated patients, 4 were untraced, 2 lived over five years after treatment elsewhere, 2 more lived over five years following irradiation alone, and 2 others who are over eighty years of age are still alive.

Ulceration may be a complication in any of the common types of breast carcinoma. It usually follows invasion of the skin by the neoplasm and serious infection may accompany it. No definite line can be drawn between those lesions which should be removed surgically and those treated primarily with irradiation because the decision is frequently dependent upon physical factors outside of the breast. Remote metastases, the condition of the axillary contents and the expected length of life represent a few such factors. As far as the local lesion is concerned, the presence of small areas of ulceration in a breast containing a slowly growing tumor which is producing contraction does not contraindicate mastectomy as previously advised. With extensive ulceration or with the more rapidly growing and widespread carcinomas, irradiation is the method of choice (Figs. 5 and 6). Associated with a large ulceration there is usually so much infection that excision or mastectomy is hazardous. Before the advent of present day methods of irradiation, it was frequently taught that most ulcerating carcinomas should be excised as a palliative measure. Today in this hospital such practice has generally been discontinued.

Irradiation of such lesions by the divided dose method is usually followed by a def-

FIG. 6. Type of ulceration in advanced breast cancer.

inite and rapid decrease of the tumor mass and also a similar decrease in the infection. The total roentgen dose to large areas using the factors previously described will vary widely in a group of such cases because some lesions will respond much more rapidly than others. In this series some patients have received as much as 3,000 r (fractionated) to areas greater than 100 sq. cm. Surgical removal of the residual local carcinoma and ulcer may be considered six to eight weeks after completion of the radiation therapy. Fixation, much residual infection, or failure of a large tumor mass to respond to irradiation usually contraindicates such a procedure.

It is generally considered that the concomitant discovery of carcinoma in each breast usually indicates the presence of a primary lesion in one and metastases in the other. Even the appearance of a tumor in the other breast at a later date, simulating a primary lesion, must be looked upon with suspicion since it is probably derived from the primary neoplasm. In this series of 920 cases there were only 10 (0.92 per cent) patients who were considered as having two breast primaries. The incidence of patients having more than one primary cancer of any type was 3.3 per cent.

Primary breast carcinoma which has metastasized to the opposite breast should be treated conservatively; there are almost certainly other metastases. Only when both lesions appear to be in an early stage and there is a reasonable possibility that both are primary in character does it seem wise to use bilateral radical mastectomy and postoperative irradiation. More advanced lesions and those in which a single lesion has probably metastasized should be treated with preoperative irradiation and the less radical surgical procedures are indicated.

The discovery of carcinoma involving the contents of the axilla in those cases classed as "operables" indicates that the average five year survival[3,5,6] following proper radical mastectomy and postoperative irradiation should be between 35 and 40 per cent. Preoperative irradiation, surgery and postoperative irradiation as reported by Pfahler[5] gives an even better prognosis (57.1 per cent) for five year survival. It is therefore of considerable importance to decide as soon as possible whether the case is suitable for a radical mastectomy combined with pre- or postoperative irradiation. At the present time in this institution preoperative irradiation and radical mastectomy are used when the axillary contents are involved. The mastectomy is performed six to eight weeks after the cessation of irradiation, and postoperative irradiation is occasionally employed. Seldom is unusual difficulty encountered in freeing the axillary contents, and the wounds heal without difficulty.

Preoperative irradiation given to produce the same intensity of skin reaction over the breast and shoulder is used when the axillary involvement is more advanced. If the axillary contents become free so that radical mastectomy is feasible six to eight weeks after the cessation of irradiation, this is performed. On the other hand, if the axilla is still fixed after irradiation or if remote extension has appeared, the radical mastectomy is not performed.

Supraclavicular metastases contraindicate radical mastectomy in our experience. It cannot be expected that the carcinoma is confined to the palpable nodes, and, therefore, there is no hope of completely removing it. Heavy irradiation should be employed and occasionally radium implantation of small residual nodes is justified as a palliative procedure.

Remote metastases from carcinoma of the breast commonly occur in the liver, bones, lungs and brain. Many do not cause symptoms until they are advanced or they affect some weight-bearing structure. Pain, the common symptom, may be caused by pressure of the growing neoplasm in bone or on nerve structure. It may also be produced by the mechanical alterations in the weight-bearing architecture when bone is destroyed. Debility, loss of weight and other manifestations of the terminal stages of the

FIG. 7. Local recurrence of breast cancer.

disease usually develop at a later date.

It does not seem advisable to treat many of the metastatic lesions by irradiation. Those which are not causing discomfort, or are not apt to cause disintegration of weight-bearing structures are best left alone. Wholesale irradiation of widespread metastases does little, if anything, to prolong the life of the patient, and adequate irradiation will probably add to the discomfort.

Metastatic involvement of the spine, pelvis, hips and ribs should receive particular attention. Lesions which destroy the structure of the long bones should be treated immediately even if they have not yet caused pain because of the possibility of fracture. If such is imminent, the part should be immobilized, or at least protected following the irradiation until sufficient time for healing has elapsed. The doses of radiation which have proved beneficial in many instances in this series are of the order of 600 r or its equivalent delivered to the site of the metastasis, the physical factors of the irradiation being the same as previously noted. Frequently, in addition to the relief of pain which usually occurs, there is roentgen evidence of bone repair. Such treatment may be repeated at two to three month intervals. It may continue to be effective in controlling the local pain as long as it is needed.

Castration by irradiation is recommended when remote metastases or local recurrences have appeared and if the patient is menstruating. The increase in cell activity seen in normal breast tissue incident upon cyclic ovarian stimulation may also be produced in the carcinoma cells of breast origin. The effect of withdrawing this stimulus may decrease the rate of growth, thus assisting the local irradiation in controlling the lesion. Prophylactic castration of the young adult who does not show evidence of residual carcinoma is not advocated. If the carcinoma has been completely removed, castration will have no beneficial effect, while the knowledge of sterility may occasionally produce great unhappiness for the patient. If residual but undiscovered carcinoma is present, it is probable that the neoplasm will reappear in spite of castration. One should, however, be less reluctant to castrate a patient near the menopause or one in whom extension beyond the operative field is suspected. Each case must be decided upon its merits, but the castration of all patients who have had breast cancer does not seem justified.

Metastases to the cranial nerves, the lungs, pleura, and other soft tissues usually respond less satisfactorily than those in the bones. Doses of irradiation as just described may be used in case of severe pain associated with the cranial nerves, rapid pleural effusion or severe dyspnea. Irradiation of the gastrointestinal tract for metastatic cancer in the liver or retroperitoneal glands usually enhances the morbidity without benefiting the patient.

Local recurrences of the carcinoma after mastectomy are not uncommon. In this series they have already occurred in 54 of the 351 patients previously treated by removal of the breast and some form of post-

operative irradiation. Such local recurrences appear in different forms. In many instances there are multiple small subcutaneous nodules of carcinoma arising almost simultaneously in and about the scar. These are soon followed by the appearance of similar small nodules throughout the chest wall. It is impractical to treat these with excision or individual applications of radiation. As a palliative measure, large portals extending well beyond the evident lesion (5–8 cm.) are used and single doses of 600–900 r are applied to each portal (half-value layer = 5.0 mm. Al, focal skin distance = 50 cm.). Such doses may be repeated in two to three months if necessary.

In another form of recurrence the carcinoma tends to remain localized in the scar, continuously increasing in size until large, hard, nodular masses are formed and ulceration occurs (Fig. 7). If such lesions are seen when they do not exceed 2 cm. in diameter, a dose of 1,000–1,500 r (half-value layer = 5.0 mm. Al, portals not in excess of 10 sq. cm.) may be applied on three consecutive occasions or a topical application of radium may be used. This treatment usually destroys the local carcinoma and may be very effective if the growth is not present in the rest of the scar. Such treatment should not be repeated to the same area. When these lesions are more extensive, a single dose of 1,000–1,500 r using the same quality of radiation may be delivered to areas up to 50 sq. cm. After using such doses it is possible to repeat this treatment in a few months.

Another type of local recurrence, which is much less common, resembles the inflammatory form described under primary breast tumor. In this instance, many foci of carcinoma rapidly appear about the scar or other residual focus and soon spread by lymphatic extension in all directions across the chest wall. The prognosis in these recurrences is very poor since the carcinoma is usually extending at a similar rate in other portions of the body. Irradiation of the chest wall for extensive skin metastases may retard the local lesion but it does not seem to materially alter the final result.

Local recurrence in an unoperated breast which has been previously treated with intensive irradiation presents a most difficult problem. It has been our experience with these cases that the subsequent dose for the recurrence must be reduced because the surrounding normal tissues will not always recover from a second application of heavy irradiation. It seems wise, therefore, to remove the breast whenever possible after the first irradiation and not delay until there is evidence of local recurrence.

SUMMARY AND CONCLUSIONS

1. Two-thirds of the 514 patients admitted without previous treatment were "operable." One-half of 162 patients who had had previous inadequate or incomplete treatment were inoperable. More than half of the 920 patients composing the entire group were either inoperable on admission or were subsequently shown to have recurrent or metastatic lesions.

2. Irradiation is the most effective single agent in dealing with advanced and recurrent breast cancer.

3. In certain cases mastectomy following irradiation will frequently improve the palliative result.

4. Recurrences were rare in the older patients with slowly growing carcinoma treated by mastectomy and irradiation.

5. Bilateral primary carcinoma of the breast was found in 0.9 per cent of the cases.

6. Prophylactic castration is not advised for every patient who has had breast cancer and is still menstruating.

7. Routine treatment of all demonstrable metastases is not recommended. However, lesions producing symptoms or causing disintegration in the weight-bearing skeletal system should be treated by irradiation.

REFERENCES

1. Adair, F. E. Effect of preoperative irradiation in primary operable cancer of the breast. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 359–370.

2. BULMER, D. J. Preliminary report on 26 cases treated with preoperative irradiation. University of Michigan, 1938. Unpublished report.
3. HUTCHISON, R. G. Value of radiation therapy in treatment of carcinoma of the breast; critical analysis of published statistics. *Surg., Gynec. & Obst.*, 1936, *62*, 653–664.
4. LEWIS, D., and RIENHOFF, W. F., JR. Study of results of operations for cure of cancer of the breast performed at Johns Hopkins Hospital from 1889 to 1931. *Ann. Surg.*, 1932, *95*, 336–400.
5. PFAHLER, G. E. Treatment of carcinoma of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 1–18.
6. PORTMANN, U. V. Classification of mammary carcinomas to indicate preferable therapeutic procedures. *Radiology*, 1937, *29*, 391–402.

DISCUSSION

DR. U. V. PORTMANN, Cleveland, Ohio. I think that we need more papers of this type but perhaps surgeons need them as much as we do. Unfortunately, we are unable to present the radiologic side of this question to surgeons as frequently as desirable.

This paper brings out two important points. First, it shows the necessity for classifying cases on the basis of the clinical manifestations of the extent of disease. Second, it brings up the question as to the proportion of patients with cancer of the breast who should be treated by irradiation at some stage of the disease. These patients who should have irradiation may be grouped in two categories: First, those presenting themselves in stages too advanced to be operable, and second, those that may be operable but the disease found to be more extensive than could be determined clinically.

There is considerable difference between operability and curability. Technically it is easy enough to take off a breast and dissect out the axilla, but the fact that the breast is superficial does not necessarily mean that a surgeon is going to successfully recover all of a cancer in it.

The authors found that 36.7 per cent of their cases were considered inoperable. The actual percentage of "incurables" would be much greater. In my experience at least 50 per cent of all cases were incurable at the time they first presented themselves as shown by what happened to them after they were operated upon.

Also, patients who have been operated upon and axillary metastases found certainly should be irradiated. This accounts for another 30 per cent as proved by statistics of surgeons which show that this proportion of patients considered "operable" were incurable. Therefore, actually radiologists should care for about 80 per cent of all cases of carcinoma of the breast.

We have had to work out our problems in regard to the technique of treatment. I believe that in the future we shall be in a better position as far as results are concerned. We know what we have been able to accomplish in the past five years and undoubtedly there will be improvement in the next five years. So I believe we should continue to treat carcinoma of the breast, give many patients palliation and extend their economic usefulness.

Vol. 44, No. 6

THE RADIATION TREATMENT OF GIANT FOLLICULAR LYMPHADENOPATHY AND ITS POLYMORPHOUS CELL SARCOMA DERIVATIVE (SYMMERS' DISEASE)*

By SIDNEY RUBENFELD, B.S., M.D.
NEW YORK, NEW YORK

WITHIN recent years there have appeared in the literature reports of a new type of lymphoid hyperplasia in the lymph nodes and spleen. Under the term of pseudoleukemia, Becker[2] in 1901 described a case with hyperplastic activity in the lymph nodes and spleen. In 1925, Brill, Baehr and Rosenthal[3] elucidated the clinical and histological characteristics. Symmers[5] added 3 additional cases in 1927 in which the term "follicular lymphadenopathy with splenomegaly" was introduced. Further elaboration of this syndrome was presented in 1931 by Baehr, Klemperer and Rosenthal[1] who used the term "follicular lymphoblastoma," and the therapeutic aspects were discussed in 1933 by Rosenthal, Harris and Kean.[4] Clinically the disease is almost always mistaken for Hodgkin's disease. Histologically, there is no resemblance.

An extensive report was submitted in 1938 by Symmers[6] who presented clinical and histological studies over a lengthy period demonstrating the capacity of giant follicular lymphadenopathy to undergo direct transformation into a polymorphous cell sarcoma having multiple foci of origin in hyperplastic lymph follicles. In addition he demonstrated the ability of giant follicular lymphadenopathy to become associated with the histologic features of Hodgkin's disease or of lymphatic leukemia. As an additional entity he described necrotic folliculitis of the lymph nodes and spleen, which represents another phase in the evolution of giant follicular lymphadenopathy with splenomegaly.

In the discussion to follow, the lymph nodes that were removed were studied histologically by Symmers. The roentgen treatment was administered with the following standard factors: roentgen rays generated at 200 kv. pulsating current, filtered through 0.5 mm. Cu and 1 mm. Al, at distances of 40–50 cm., and milliamperage of either 10 or 20 depending upon the machine. Treatments were given with adequate sized portals at two or three day intervals. The unit dose was either 100 to 150 to 200 r, measured in air.

CASES OF GIANT FOLLICULAR ADENOPATHY

CASE 1. J. H., aged forty, was seen in October, 1933, because of loss of weight, and a burning sensation in the feet of seventeen weeks' duration. Examination revealed the spleen enlarged to a point 15 cm. below the costal margin, nodes in the epitrochlear, inguinal and axillary regions enlarged to 1–2 cm. These nodes were firm, non-tender, and freely movable. The liver was felt one fingerbreadth below the rib margin. The blood count revealed a relative lymphocytosis of 55 per cent in a total white count of 4,200.

Histologic examination of several lymph nodes removed from the left axilla showed widespread numerical and dimensional hyperplasia of the follicles. The follicles were composed largely of hyperchromatic embryonal cells of the large lymphocytic type.

Treatment with high voltage roentgen rays was given to the alternate anterior and posterior splenic areas every third day with the standard factors outlined before, for a total dose of 800 r to each area. Two months after the completion of treatment, the spleen and liver had receded and were not palpable, the adenopathy had completely disappeared. The burning sensation in the toes was no longer felt. Regain of the 25 pounds previously lost restored the patient to health. He has remained well for five years. The lymphocyte count became normal.

* From the Radiation Therapy Service, Dr. Ira I. Kaplan, Director, of the Bellevue Hospital, New York.

Case II. D. W., female, aged nineteen, a dietitian, was seen in September, 1936, with enlarged nodes on both sides of the neck. Several months previously she observed three nodes in the right axilla. These nodes were tender, and one eventually ruptured to discharge a thin cream-colored material for about three weeks and then healed. Examination on the September admission revealed a mound-like mass of nodes in the right supraclavicular area. In each submaxillary zone, there was a 1 cm. discrete, non-tender node. The axillary lymph nodes on both sides were enlarged to the number of five or six and were not tender. The spleen and liver were not palpable. The blood count showed no abnormal changes. Microscopic study of a group of nodes removed from the left axilla disclosed almost complete replacement by massive lymph follicles. The germinal centers stained lightly and were composed almost exclusively of hyperchromatic embryonal cells of the large lymphocytic type with a slight admixture of large hypochromatic cells.

Roentgen therapy was administered to the left submaxillary node in doses of 100 r through a 6×8 cm. portal and at a distance of 40 cm., at weekly intervals. One single dose of 100 r was given to the right axilla in addition to the neck area at the time of the second treatment. The neck received only four treatments. At the completion of this series, all nodes had disappeared. The patient has remained free of adenopathy for three years.

Case III. H. D., male, aged fifty-four, was first observed in December, 1936, with enlarged nodes in the submental and inguinal areas. In 1934, the patient noticed enlarged nodes in both axillae. Soon, there appeared similarly enlarged nodes in both inguinal areas, and in both sides of the neck nodes of even larger dimensions were felt. In April, 1935, roentgen treatment was given elsewhere, and after seven such treatments the nodes were considerably reduced in size. Two months later, shortness of breath became severe enough to necessitate hospitalization at another institution, where thoracentesis released 400 cc. of cloudy yellow fluid. During the next six weeks, five additional chest punctures withdrew 1,700, 1,500, 2,000, 2,500 and 2,000 cc. of fluid, respectively. The blood count on numerous occasions showed a mild secondary anemia and a relative lymphocytosis up to 40 to 50 per cent lymphocytes in the presence of a total white count of 4,000 to 5,000.

The initial examination in our clinic in December, 1936, disclosed enlargement of the submental, bilateral axillary and inguinal nodes up to 2 cm. all movable and non-tender. A 3 cm. movable tender nodule was present in the areola of the left breast. Re-examination of the lymph node removed for biopsy in December, 1934, showed excessive hyperplasia of the lymph follicles. Many of them were enormous, others were considerably above the average size, while a few were of limited dimensions. The germinal centers were made up largely of loosely packed, large hypochromatic embryonal cells together with an admixture of hyperchromatic embryonal cells of the large lymphocytic type. In April, 1937, a solitary lymph node remaining in the right side of the neck was removed at Bellevue Hospital and the same histologic changes were evident.

Because of the unusual and untoward reactions in this patient, roentgen therapy was administered in inadequate doses and at irregular intervals. With the standard factors outlined previously, and in unit doses of 100 to 150 r, three treatments were given to the anterior mediastinum, two to the left inguinal, and three to the submental areas, at five day intervals and in alternation. After the third treatment, pyrexia of 102° F. developed. Observation after six treatments showed regression in the size of the nodes, with appearance of new nodes in the epitrochlear regions. Subsequent follow-up in the home disclosed regression of the nodes, but the chest changes recurred and persisted until the patient died late in 1937. Postmortem examination was not made.

Case IV. K. S., female, aged sixty-one, a housewife, was seen in September, 1938. The patient had noticed the appearance and slow growth of a lump in the right side of the neck below the angle of the jaw since July of the same year. She was oblivious to the presence of other adenopathy. There was no pain or any discomfort associated with the enlarged node in the neck. Examination revealed a group of nodes in the right posterior cervical chain, single enlarged nodes in both inguinal areas, and several in the left axilla. Those in the groins measured 3 cm. in length, and all were freely movable and not tender. The spleen was enlarged to three fingerbreaths below the costal margin, was smooth but of firm consistency. The general condition of the patient was well maintained. The blood count was normal.

Treatment with high voltage roentgen rays was commenced using the standard factors outlined, and alternation between the various sites of adenopathy and the spleen. With unit doses of 150 r, the spleen received 900 r, the cervical gland 1,000 r, and both inguinal regions 1,200 r to each. At the end of the third treatment all the nodes and the spleen exhibited a regression in size, and at the end of the series, there was a total disappearance of all nodes and the spleen was no longer palpable. The patient has remained well for over eight months.

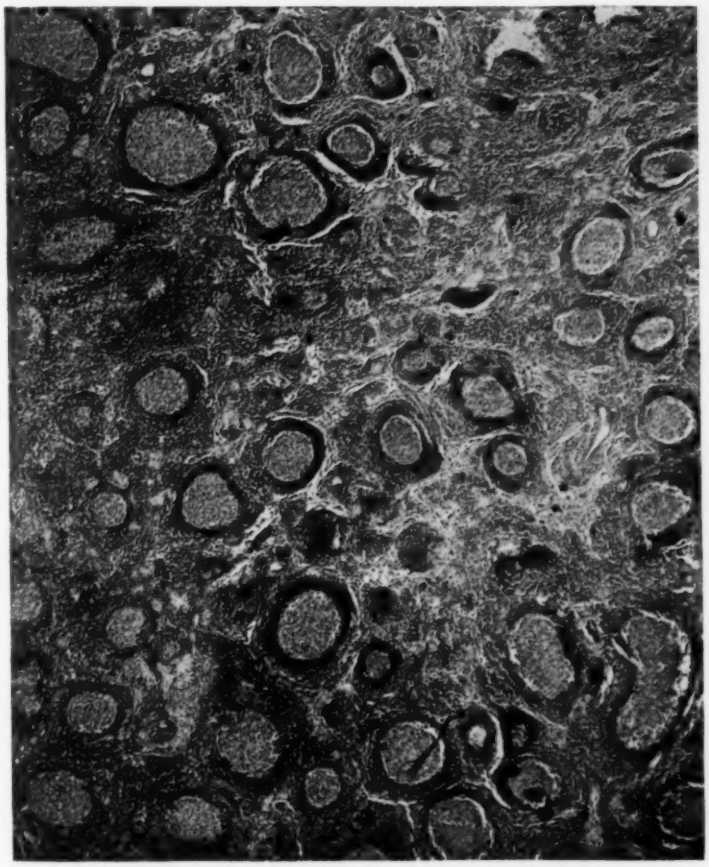


Fig. 1. Very low power photomicrograph showing numerical and dimensional hyperplasia of the lymph follicles in giant follicular lymphadenopathy, with an extensive degree of interfollicular fibrosis.

SUMMARY AND COMMENT

The clinical entity of giant follicular lymphadenopathy is characterized by generalized enlargements of the superficial nodes with or without splenomegaly. The nodes vary in size from 1 to 3 cm. in diameter or more, are discrete and movable, non-tender, and of firm consistency. Histologically (Fig. 1) the nodes show numerical and dimensional hyperplasia of the lymph follicles which are delimited by a zone of deeply staining small lymphocytes. The germinal areas may be made upof large hypochromatic embryonal cells, and relatively deeply staining small embryonal cells of the large lymphocytic type. Splenic enlargement is likewise due to lymph follicle hyperplasia.

The extreme degree of radiosensitivity is well established, as observed in the cases herein reported, and its histological explanation may lie in the embryonic character of the cells. Small doses are adequate and treatment need not be intense individually

or totally. After one or several treatments the nodes will begin the process of recession, and treating one area may evoke response in a distant non-irradiated region.

In 2 patients in this series, a moderate relative lymphocytosis which accompanied the adenopathy disappeared as the nodes regressed in size.

Although only one patient is recorded after a period of five years, nevertheless by the behavior in that one patient it may be not unreasonable to presume that the disease is not arrested, but actually cured by mild doses of roentgen therapy.

CASES OF POLYMORPHOUS CELL SARCOMA OF HYPERPLASTIC LYMPH FOLLICLES

CASE I. M. C., female, aged forty-one, was seen in June, 1938, with a widely disseminated skin eruption of ten months' duration. There was a history of malaria twenty years before. Four years prior to this observation, a 4 plus Wassermann reaction was detected for which a long series of injections was given. Ten months previous to admission, a rash developed over both lower extremities and slowly progressed to involve the entire body. Examination revealed a diffusely distributed maculopapular eruption of pink color with many of the areas oozing a serous discharge. Numerous scratch marks were present. In the inguinal, femoral and axillary zones were palpable chains of lymph nodes varying from 1 to 4 cm. in diameter, firm in consistency, and freely movable. The spleen was not felt. The Wassermann reaction was 4 plus. A small skin area under the microscope gave a picture of dermatitis exfoliativa. A lymph node removed from the axilla showed follicular lymphadenopathy with transformation into polymorphous cell sarcoma.

The right and left axillae, and the right and left inguinal (including the femoral) areas were treated with roentgen radiation, exposing two areas at a time and alternating every second day. With unit doses of 150 r at 50 cm. distance, treatment was continued until each node bearing zone received 1,500 r. There followed only slight reduction in the size of the larger nodes.

CASE II. S. C., male, aged thirty-eight, was admitted in August, 1938, with a generalized body eruption of two years' duration. The patient was employed in a plumbing supply house (twenty years) when a slight dry exfoliation with mild itching appeared over both lower extremities. With slow progression the entire body became covered with a rash of similar character. Itching became more intense, and numerous lotions and ointments failed to effect any change except that an oily ointment relieved the itching.

When observed in August, 1938, there was a generalized, fine, flake-like scaliness with severe itching. In both axillae, inguinal and femoral regions, there were felt firm movable nodes of 1–3 cm. in diameter. The spleen was not palpable. Blood counts showed no abnormal findings aside from an increase of eosinophiles up to 8 per cent.

This patient received only 300 r to each area, and failed to return. However, four months later, upon his reappearance at the clinic, all the nodes had increased in size, and in addition, enlarged epitrochlear nodes appeared. A dose of 900 r to the axillary, supraclavicular and epitrochlear nodes was sufficient to induce regression. However, as much as 3,000 r was necessary to dissolve the inguinal chain. During the course of therapy, a nodule appeared in the areola of the right breast. This was controlled with a dose of 1,500 r. The skin lesion remained unchanged during this interval.

CASE III. H. M., female, aged twenty, was seen first in February, 1938, complaining of swollen nodes in her neck, which had appeared one month previously. There were no other associated symptoms. Physical examination revealed numerous nodular enlargements in the cervical, submaxillary, axillary and inguinal zones. They were all firm, discrete, freely movable and not tender. The blood count was normal. The spleen was not felt.

Histological examination of a group of glands excised from the axillary area showed polymorphous cell sarcoma. In view of the fact that this patient made comment upon the fact that the nodes showed evidence of spontaneous regression the decision was made to withhold treatment for a period to observe their behavior. From March until September, 1938, no treatment was administered and there was some reduction in the size of some of the nodes especially those in the inguinal zones. Those in the axillae and cervical chains were larger. This patient is still being observed without treatment.

CASE IV. J. B., male, aged thirty, entered Bellevue Hospital in May, 1937. He complained

of a painful lump in the left side of the neck of six months' duration. Examination revealed in the left side of the neck an ovoid mass measuring 4 cm. in diameter, firm, discrete and not tender. On the right side of the neck, there was a chain of four moderately enlarged nodes lying beneath and behind the sternomastoid muscle. There was no other adenopathy and the spleen was not enlarged. The blood Wassermann was negative and the blood count showed no alteration.

At this time a cervical node was removed, and histological examination showed replacement of its normal architecture due to moderate numbers of hyperplastic lymph follicles, the germinal areas of which were made up of large hypochromatic cells with transitional forms and a few hyperchromatic cells of the large lymphocyte type.

In May, 1937, roentgen treatment to both sides of the neck was commenced, one side at a time and alternating every third day. When each side had received 2,200 r, treatment was curtailed because of failure to evoke regression. That series involved a period of three months. After a rest period of six weeks, a second course of treatment was given in which the filter was augmented to 1 mm. Cu to increase the hardness of the ray. At the termination of the second series totalling 2,400 r to each side of the neck, the nodes had completely regressed. Shortly thereafter, the patient complained of pain in the lumbar vertebrae. Roentgen examination showed dense sclerosis of the body of the fourth lumbar body with similar changes in the fifth as well as the left sacroiliac region. A dose of 1,500 r to the lumbar areas failed to relieve the pain. The patient left the clinic and died at home in June, 1938, one year after admission to the hospital.

Case v. L. K., male, aged forty-three, was admitted to Bellevue Hospital in February, 1937, complaining of a skin disorder of nine years' duration. There was severe itching, scaling and weeping sores distributed over the entire body. Numerous ointments and lotions gave temporary relief. Several days after admission enlarged nodes were detected in both axillae, both inguinal and femoral areas. They presented as grape-like bunches, all hard, discrete, movable and varying in size from 0.5 to 3 cm. in diameter. The spleen was not felt. The blood count was normal.

Microscopic examination of an excised inguinal node revealed numerical and dimensional hyperplasia of the lymph follicles. The centers of the follicles were composed of great numbers of hypochromatic shadow-like cells intermingled with transitional cells and cells of the large lymphocytic type. Ruptured follicles were numerous. Silver impregnation for reticulum cells showed none.

Roentgen therapy was started over the involved zones alternating between the areas at two day intervals. Following a dose of 700 r to each area, there was a slightly perceptible diminution in the size of the nodes. Because of the extreme degree of incapacitation produced by the exfoliating dermatitis, treatment was temporarily suspended and then resumed for an additional dose of 900 r to each area. With this second series, the dermatitis showed improvement and 900 r additional was administered to the node bearing zones. Six months later all nodes had disappeared. They are absent at the end of two years.

Case vi. G. B., male, aged ten, came to the clinic in June, 1938, complaining of swelling of both sides of the neck. For the past several years, the patient suffered from repeated sore throats with accompanying cervical adenitis. One year prior to admission, a tonsillectomy was done, and soon therafter bilateral swellings appeared in the anterior supraclavicular areas. They did not increase in size. Examination revealed enlarged nodes in the axillary and cervical areas. In both supraclavicular zones, there were many discrete, semi-firm nodes, non-tender. The spleen was not palpable. The blood count was normal.

Histological study of a group of nodes removed from the neck showed transformation of giant follicular lymphadenopathy into polymorphous cell sarcoma of the lymph follicles.

A roentgenogram taken at that time revealed mediastinal adenopathy on both sides. Roentgen therapy was given to the anterior mediastinum and both sides of the neck utilizing the factors outlined before at 40cm. distance. Both neck areas were treated at one sitting, and these alternated with the mediastinum at three day intervals. In unit doses of 100 r, total doses of 600 r were given to each of these three areas. The next month, all nodes were greatly reduced in size but were still palpable. At the end of an interval of two months, additional therapy was given to both sides of the neck and both axillary zones. The latter received 700 r and the former

an additional 500 r in unit doses of 100 r. At the completion of this cycle of treatment, all nodes had disappeared, and the mediastinal shadow approached the normal.

CASE VII. F. L. B., male, aged twelve, was seen in July, 1938, presenting lumps in the neck and axillae. The condition was discovered only one week before when the mother noticed a "knot" in the left axilla. The lump was red and painful at first, but soon subsided. Although this node did not increase, others appeared. There was no pain or discomfort. The tonsils had been removed. Examination showed a slightly undernourished but otherwise normal boy with enlarged nodes in both axillae, submaxillary, epitrochlear and inguinal areas. They were hard, discrete, not tender, varying in size from 1–2 cm. in diameter.

Histological examination of an excised node revealed polymorphous cell sarcoma of the lymphoid follicles.

Roentgen therapy was given to the right and left axillae. In unit doses of 100 r, a total of 700 r was administered to the right side and 500 r to the left, but with little response. After a lapse of one month, these areas were again irradiated, but the unit dose was increased to 200 r, and the left cervical area was added. At the end of this cycle, during which treatment was given at three day intervals, the nodes in the right axilla disappeared with 1,400 r, and those in the left neck with 800 r. The node in the left axilla

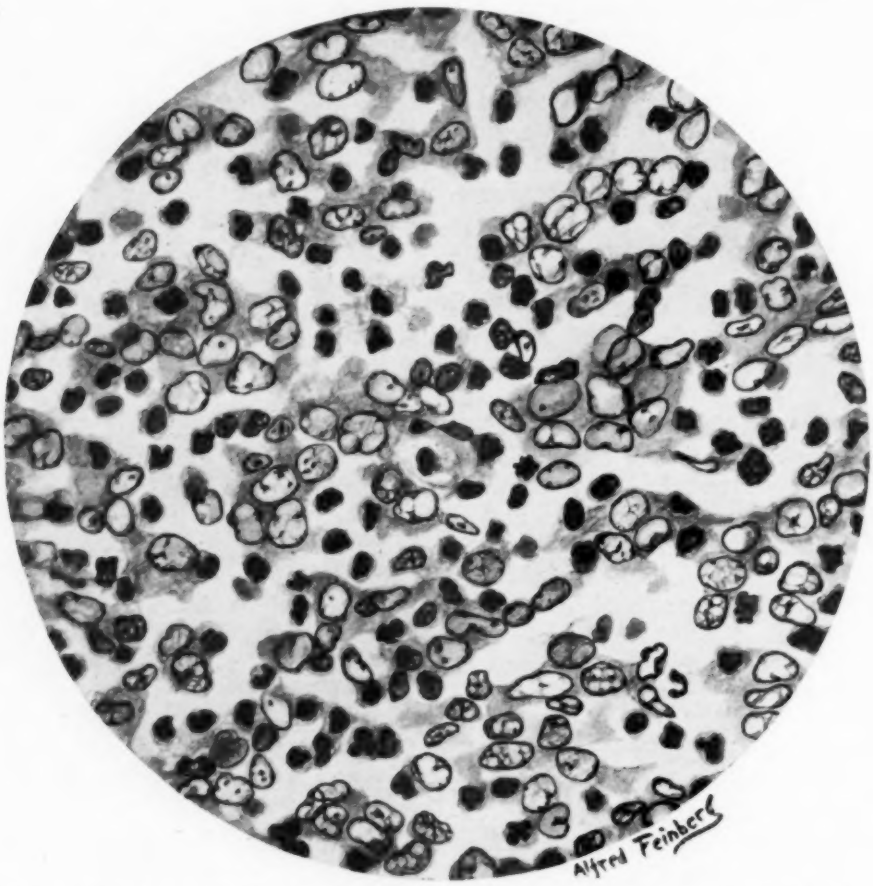


FIG. 2. Drawing to illustrate cell types in the polymorphous cell sarcoma following neoplastic transformation of giant follicular lymphadenopathy: large hypochromatic or shadow cells; smaller, slightly chromatic transitional cells, and hyperchromatic cells of the large lymphocytic type. Oil immersion lens.

persisted, though somewhat smaller in size, even when 2,000 r was given. Subsequently, these nodes disappeared.

Case VIII. J. P., colored male, aged forty-five, was first admitted to Bellevue Hospital in 1930 presenting a mass on the right side of the neck. This mass had first made its appearance three years previously, grew slowly, but was not accompanied by pain or discomfort. No other adenopathy was evident. The blood count was normal. Histological examination of the excised gland revealed Hodgkin's disease. The area in the right neck received but 600 r. The patient did not report to the clinic for eight years when nodes appeared in the axillary and supraclavicular areas. One node removed from the neck presented, under the microscope, diffuse dimensional and numerical hyperplasia of the follicles, many of which showed cell morphology indicative of polymorphous cell sarcoma.

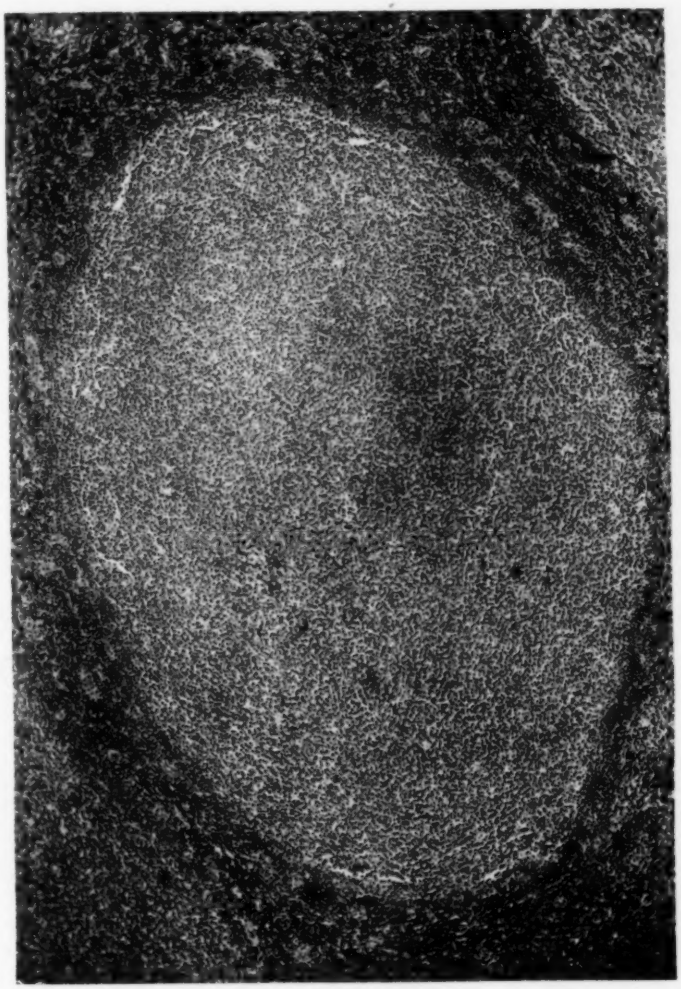


Fig. 3. Lower power photomicrograph to illustrate giant follicular lymphadenopathy as a precursor of polymorphous cell sarcoma of lymph nodes. Note intact follicle.

Doses of 1,500 r were sufficient to cause regression in the nodes.

DISCUSSION

That Symmers' disease presents characteristics different from the usually recognized lymphomas is well exemplified in the cases herein presented. There were 6 males and 2 females, none over forty-five years of

age, and 3 were in the second decade. There were 3 patients in whom long standing, weeping skin lesions preceded the development of the adenopathy. Whether the generalized dermatologic changes were the causative factor in the hyperplasia of the lymph nodes is a question, but, based upon a hypothesis of infection, such a sequence of events appears plausible.

Morphologically, the large hypochromatic cells, or shadow cells are traceable through smaller transitional cells into still smaller hyperchromatic cells which resemble large lymphocytes. All these cells are derived from follicles which are set aside for the purpose of producing lymphocytes. These cells are probably immature lymphocytes showing histologic variations. Symmers chooses to employ the term polymorphous cell sarcoma rather than lymphosarcoma until more conclusive evidence is found that the unit of growth is a lymphocyte (Figs. 2, 3 and 4).

There are two distinct clinical signs which give substantiation to the belief that these nodes are not in the nature of either Hodgkin's disease or the familiar lymphocytic lymphosarcoma. First, these nodes were slow growing. Cases III, IV and VIII were observed over long periods during which interval the nodes did not grow noticeably. Secondly, the nodes proved radioresistant. From the viewpoint of roentgen therapy, it has been almost axiomatic to believe that

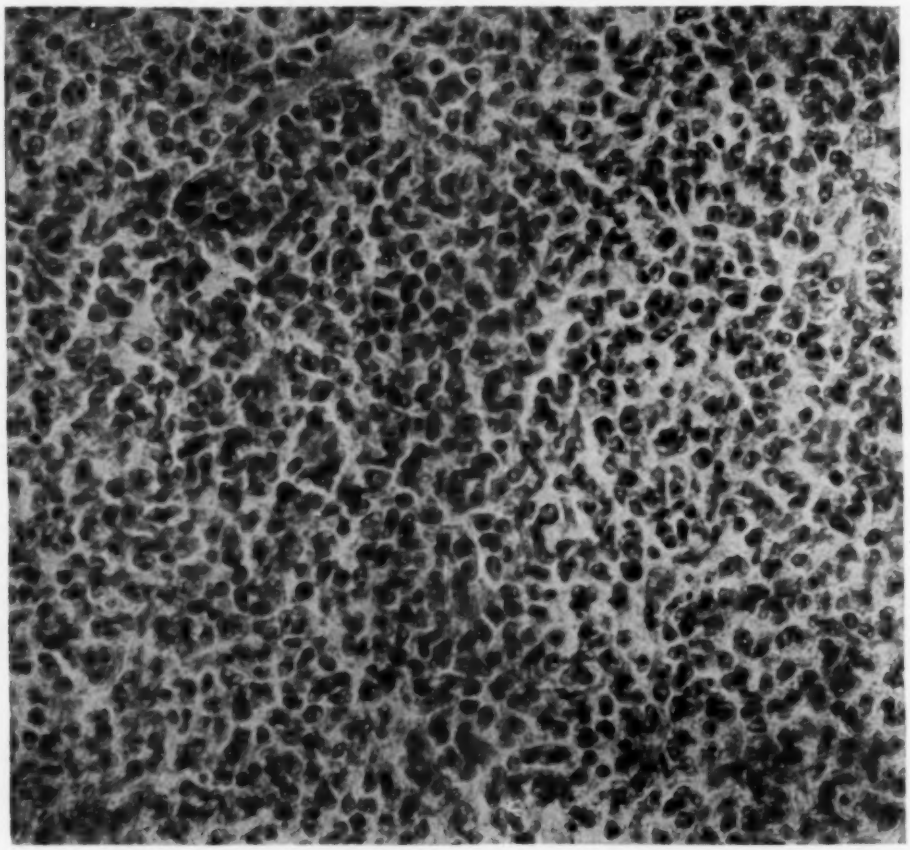


FIG. 4. High power photomicrograph taken from a ruptured follicle in the case shown in Figure 3, to illustrate polymorphous cell sarcomatous transformation of giant follicular lymphadenopathy. It shows infiltration of the body of the node by hordes of large hypochromatic or shadow cells and smaller hyperchromatic cells of the large lymphocytic type.

the most radiosensitive tumors are the lymphosarcomata. Case v was diagnosed as one of lymphosarcoma, and treatment was instituted. However, following 2,200 r, with the factors outlined previously, the nodes did not recede. Such behavior is contradictory to all experiences with lymphosarcoma. Case v received a total of 2,500 r in three cycles before the glands began to recede. Varying reactions were noticed in the nodes of Case viii. One chain of nodes disappeared following 800 r, another following 1,400 r, but one node in the left axilla persisted in spite of a dose of 2,000 r. In this connection, it may not be unreasonable to hypothesize that there may have been a gradation of stages in the development of a polymorphous cell sarcoma from the giant follicular lymphadenopathy. The latter stage, as indicated previously, will show rapid regression under the influence of therapy, and the sarcoma stage will exhibit greater resistance. Only in Case vi was there complete disappearance of the enlarged nodes at the end of a relatively milder dose of 1,300 r to each area. However, by contrast, a much quicker response would be expected were we treating a lymphosarcoma.

CONCLUSIONS

1. Giant follicular lymphadenopathy presents a characteristic histological picture. It is rapidly amenable to small doses of roentgen therapy.

2. Polymorphous cell sarcoma is a disease entity derived from a proliferation of cells which eventually rupture from a large follicle in giant follicular lymphadenopathy. This was first described by Symmers.

3. The greater frequency is found in males in the middle span of life.

4. The enlarged nodes of polymorphous cell sarcoma may persist for long periods of time.

5. There may be some association between long standing, weeping skin lesions and the evolution of polymorphous cell sarcoma.

6. In contradistinction to the extreme radiosensitivity of the nodes of giant follicular lymphadenopathy, the nodes of polymorphous cell sarcoma are radioresistant, but may show regression after intense doses of roentgen radiation.

7. The factors and technique of roentgen therapy in these conditions are presented.

REFERENCES

1. Baehr, G., Klemperer, P., and Rosenthal, N. Follicular lymphoblastoma (giant follicular hyperplasia of lymph nodes and spleen). *Am. J. Path.*, 1931, *7*, 558–560.
2. Becker, E. Ein Beitrag zur Lehre von den Lymphomen. *Deutsche med. Wchnschr.*, 1901, *27*, 726–728.
3. Brill, N. E., Baehr, G., and Rosenthal, N. Generalized giant lymph follicle hyperplasia of lymph nodes and spleen. *J. Am. M. Ass.*, 1925, *84*, 668–671.
4. Rosenthal, N., Harris, W., and Kean, A. Clinical and radiotherapeutic considerations of follicular lymphoblastoma. Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 95–104.
5. Symmers, D. Follicular lymphadenopathy with splenomegaly. *Arch. Path.*, 1927, *3*, 816–820.
6. Symmers, D. Giant follicular lymphadenopathy with or without splenomegaly. *Arch. Path.*, 1938, *26*, 603–647; correction, 1938, *26*, 1092.

BENIGN GIANT CELL TUMOR OF BONE

FIVE YEAR CURE*

By LOUIS EDEIKEN, M.D.
PHILADELPHIA, PENNSYLVANIA

BENIGN giant cell tumor of bone is a relatively uncommon condition. Its roentgenologic appearance and clinical aspects are fairly striking and characteristic so that the diagnosis can readily be made in the great majority of cases.

However, the treatment of giant cell tumor of bone is still controversial. There are those who believe that surgery is the method of choice. For a number of years before the benign nature of this tumor was recognized, amputation was advised when the lesion involved one of the long bones. However, Bloodgood in 1910 and 1912 suggested the more conservative method of treatment. Since then, resection or curettement has been the surgical procedure used. The latter is the more popular. In several instances, surgery was followed by irradiation.

FIG. 1. Lateral view. Large destructive lesion involving the lower end of the right femur, before irradiation.

Roentgen therapy alone in the treatment of benign giant cell tumor was used by Pfahler in 1906. Herendeen made his reports on the roentgen therapy of giant cell bone tumor in 1930 and 1931. Since then irradiation alone has been advocated by many as the preferred method of treatment. Because the mode of treatment of giant cell bone tumor is controversial, a "five year cure"

FIG. 2. Anteroposterior view.

* From the Department of Radiology, Mount Sinai Hospital, Philadelphia.

by any method should be interesting and worthy of report.

The case we are reporting is a giant cell tumor of the lower end of the femur, which was treated by irradiation alone and in which we obtained a "five year cure."

A. R., female, single, aged twenty-four, was admitted to Mount Sinai Hospital on October 6, 1932, with the chief complaint of slight pain in the right knee associated with limping for the last five months. There was a slight loss in weight. The pain was present at all times, even while in the lying position, but was more marked upon weight-bearing. She walked with her right knee stiff because of a sense of insecurity. There was a decided globular enlargement of the right knee, especially evident on the medial aspect. There was muscular atrophy of the quadriceps extensor. The knee cap was freely movable. The overlying skin was normal. There was no muscular spasm and the joint movements were normal. The physical examination failed to reveal any abnormality, other than those found in the right knee. All laboratory tests, including the Wassermann reaction, were normal.

Roentgen examination made on October 11, 1932, of the right knee disclosed the following: "There is a large destructive lesion involving the medullary cavity just above the internal condyle of the right femur along its posterior aspect. It has thinned out and involved the cortex. There is no evidence of periosteal proliferation or new bone formation. Its appearance and location lead me to believe that we are dealing with a neoplastic lesion, most likely the osteolytic form of giant cell tumor" (Figs. 1 and 2).

An aspiration biopsy was done and the pathological report by Dr. David Meranze on October 14, 1932, was as follows:

Specimen: Tissue from bone (femur).

Macroscopic: The specimen consists of a few tiny shreds of whitish tissue.

Microscopic: (Fig. 3) The bits of tissue presented consist chiefly of round cells with a few admixed spindle cells. All of these cells are approximately of the same size. Their nuclei are not hyperchromatic. Only occasional mitoses are seen. In addition are many other irregularly disposed giant cells, in whose centers are usually present many vesicular nuclei. No dense hyaline or osteoid bands are present. Vascularity is prominent.

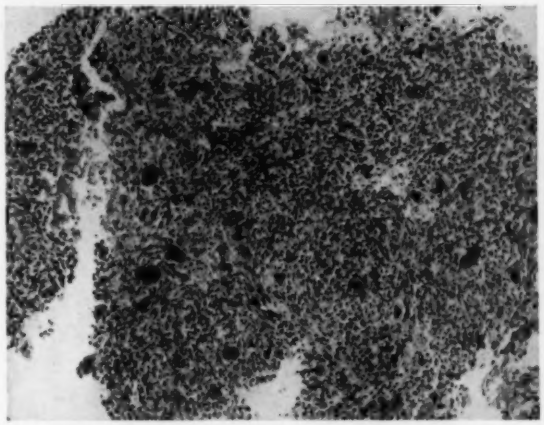


Fig. 3. Microscopical section of aspiration biopsy. Tissue consists chiefly of round cells, with a few spindle cells. Diagnosis: giant cell tumor of bone.

Diagnosis: Giant cell tumor of bone.

Irradiation was advised and instituted on October 18, 1932. The following factors were used: 200 kv., 5 ma., 0.5 mm. Cu and 2 mm. Al, 50 cm. distance.

10–18–32	160 r to right knee, anterior and posterior
10–22–32	160 r to right knee, anterior and posterior
10–24–32	160 r to right knee, anterior and posterior
10–26–32	160 r to right knee, anterior and posterior
10–31–32	160 r to right knee, anterior and posterior
11– 2–32	160 r to right knee, anterior and posterior
Total—	960 r to right knee, anterior and posterior, first series.
1–18–33	160 r to right knee, posterior
1–20–33	160 r to right knee, posterior
1–23–33	160 r to right knee, posterior
1–25–33	160 r to right knee, posterior
1–27–33	160 r to right knee, posterior
1–30–33	160 r to right knee, posterior
2– 1–33	160 r to right knee, posterior
2– 3–33	143 r to right knee, posterior
Total—	1263 r to right knee, posterior, second series.

Roentgen examinations were made at frequent intervals following irradiation and a gradual and continued improvement was observed in the roentgenographic appearance. The last examination made on October 26, 1937 (Figs. 4 and 5) shows what we believe to be a complete "five year cure" of the giant cell tumor as evidenced by the regeneration of bone in the de-

Fig. 4. Anteroposterior view. Five years after irradiation, showing regeneration of bone.

Fig. 5. Lateral view of the same.

stroyed area in the lower end of the femur. Clinically, the patient is completely cured. The lower extremity has a normal appearance. There is no limitation of movement and no pain, discomfort or other symptoms referable to the knee joint.

SUMMARY

A case is reported of giant cell tumor of the lower end of the femur treated by irradiation only and in which a "five year cure" was obtained. Physical examination at the present time shows the knee to present a normal appearance and there is no limitation of motion. The last roentgenographic examination made five years after irradiation was instituted shows a complete regeneration of bone.

REFERENCES

1. Geschickter, C. F., and Copeland, M. M. Tumors of Bone. American Journal of Cancer, New York, 1931.
2. Herendeen, R. E. Roentgen ray in treatment of giant-cell tumors. Am. J. Roentgenol. & Rad. Therapy, 1924, *12*, 117–125.
3. Herendeen, R. E. Results in röntgen-ray therapy of giant-cell tumors of bone. *Ann. Surg.*, 1931, *93*, 398–411.
4. Pfahler, G. E., and Parry, L. D. Treatment of giant-cell bone tumors by roentgen irradiation. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 151–166.
5. Richards, G. E., and Singleton, A. C. Giant-cell tumors of the spine. *Radiology*, 1938, *30*, 43–51.

Vol. 44, No. 6

TERATOMA (MIXED TUMOR) OF THE RIGHT PAROTID GLAND WITH METASTASIS TO STERNUM AND SECOND RIB LEFT

CASE REPORT

By S. K. LIVINGSTON, M.D., F.A.C.S.
HINES, ILLINOIS

A REASONABLE search of the literature reveals no information relative to skeletal metastasis in teratoma (mixed tumor) of the parotid gland. Because of the relative infrequency of this condition, the following case is reported.

CASE REPORT

T. R. A. (Reg. No. 76258). A colored male, aged forty-four, occupation cook, was admitted March 18, 1937, for treatment right parotid tumor (mixed) recurrent.

Chief Complaint. Pain and swelling right jaw and left shoulder.

Family History. Negative.

Past History. Usual diseases of childhood. Gonorrhea and chancre in 1926. Tracheotomy in July, 1935.

Present Illness. A right parotid tumor was removed in 1928. No further symptoms until the spring of 1934 when a recurrent nodule appeared in the region of the angle of the jaw on the right which grew rapidly. There was 20 pounds loss of weight. In 1935 a tracheotomy was done because of gradual infiltration of the lower jaw, pressure upon the hard and soft palate, pharynx and trachea. In October, November, and December, 1935, 4,057 roentgens, deep roentgen therapy, was given to the right side of the face and neck, surgery not being deemed advisable. In 1935 roentgenograms of the thoracic framework, revealed no evidence of metastasis. A right facial paralysis developed in June, 1935. When seen in May, 1936, there was some decrease in the size of the tumor due to previous irradiation. Surgery and further irradiation were not considered necessary. Palliative relief from irradiation lasted from December, 1935, to January, 1937, when pain returned

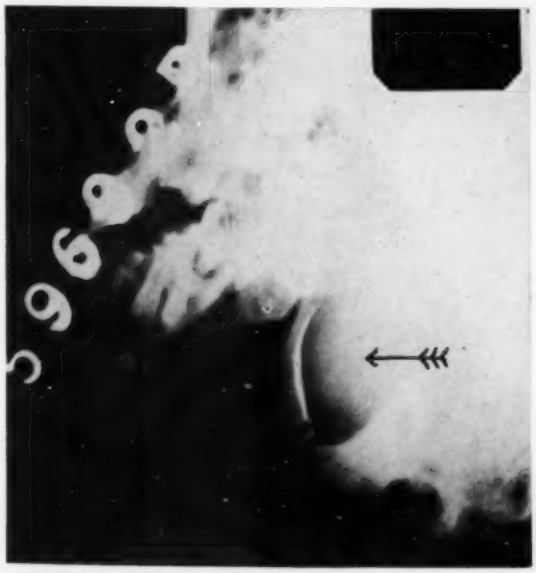


FIG. 1. Roentgenogram of right mandible showing destruction of bony tissue by metastasis.

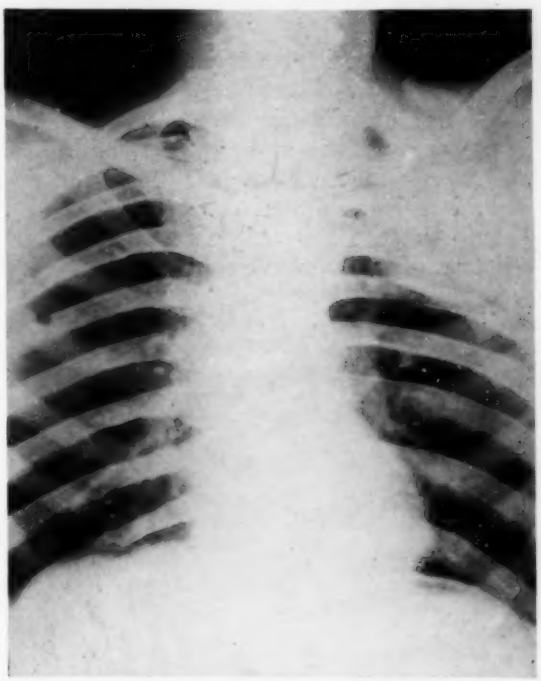


FIG. 2. Roentgenogram revealing large tumor mass in upper left anterior chest wall.

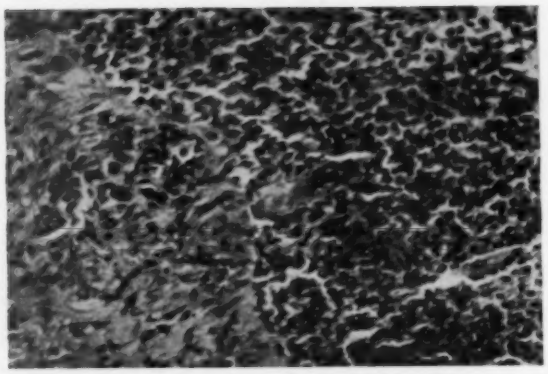


FIG. 3. Photomicrograph of tissue from right parotid gland showing a tumor composed of fairly uniform, small, lightly staining polyhedral cells. Mitotic figures are present but not numerous. In places the cellular structure takes on a mucoid appearance.

to the right parotid region and the left shoulder became sore and swollen.

Physical Examination March, 1937. The patient was cachectic and chronically ill. There was a large hard indurated mass in the right parotid region. Paralysis of right facial nerve was still present, and patient was able to breathe satisfactorily through the tracheotomy tube. In the left anterior chest wall beneath the skin was seen a large tender mass the size of an orange, causing pain in the left arm and impairment of function. There was a nodule over the sternum, 2 cm. in diameter. A roentgenogram of the chest taken at this time showed partial destruction of the second, third, and fourth ribs on the left in their axillary portions. The laboratory findings were within normal limits.

In April, 1937, 1,200 r was given to the right parotid region. Death occurred on May 29, 1937.

Histological Report (Slide No. 31831). Tumor composed of fairly uniform, small, light-staining polyhedral cells. Mitotic figures are present but not numerous. In places cellular structure takes on a mucoid appearance. Diagnosis, mixed tumor.

A postmortem examination was done and the anatomical diagnoses were: (1) Teratoma (mixed tumor) right parotid gland with metastasis to lungs, liver, spleen, left adrenal, gallbladder, sternum and second rib left; (2) lobar pneumonia; (3) cloudy swelling myocardium and kidneys; (4) chronic passive congestion of liver; (5) chronic cystitis; (6) pathological fracture second rib left; (7) tracheotomy wound.

Vol. 44, No. 6

A MEASUREMENT OF GAMMA RADIATION IN ROENTGENS*

By T. N. WHITE,† Ph.D., L. D. MARINELLI, M.A., *and* G. FAILLA, D.Sc.
Biophysical Laboratory, Memorial Hospital
NEW YORK CITY

1. INTRODUCTORY OUTLINE

IN A previous paper[1] two of the present authors described a measurement of the ionization which occurred in the air between two concentric spherical shells of bakelite when a source of filtered gamma radiation was placed at the center. A value of 111 roentgens was deduced as the quantity of gamma radiation delivered in one minute at one centimeter distance from one gram of radium. This value was about 20 per cent below other precision values obtained by the thimble chamber method.[2,6,10,11] The reason for this discrepancy was not clear, and an investigation with spherical shell chambers of different dimensions was undertaken in order to study the variation of the discrepancy with geometrical conditions. This study has been completed, and it is now possible to offer an explanation which is of importance in relation to the general conditions of applicability of the thimble chamber method. Further, a thorough consideration of various corrections and sources of error permits a fairly precise evaluation in roentgens of the quantity of filtered gamma radiation delivered in unit time at unit distance from unit quantity of radium.

There will first be discussed briefly the known conditions of applicability of the thimble chamber method. Attention will be drawn to certain current ideas concerning the practical importance of the divergence of the rays passing through a thimble chamber. The influence of this factor will then be examined mathematically in the case of a spherically symmetrical arrangement with the aid of simplifying assumptions. The results of this analysis will be shown to provide a qualitatively satisfactory explanation for the discrepancy referred to above. The formula obtained will then be tested against the experimental data now available. It will be shown that the variation of the observed ionization with varying geometrical conditions can be theoretically explained with surprising accuracy.

2. CONDITIONS AND DEFINITIONS OF TERMS

The quantity in roentgens of filtered gamma radiation delivered in unit time at unit distance from unit quantity of radium is indefinite unless certain additional conditions are specified. Suitable additional conditions will now be specified and the resulting quantity which should be a physical constant will, for brevity, be referred to as the "specific effective gamma-ray intensity of radium." The word "effective" is used merely as a reminder that we are concerned with the measurement of radiation in roentgens rather than in absolute energy units. Effective intensity is then taken to mean the quantity in roentgens of radiation delivered per unit time at any point. In order that the effective intensity at unit distance from the source be determinate, it is specified that the source be punctiform and that both source and point of measurement be surrounded by a non-attenuating medium. It is specified that the unit quantity of radium* in the idealized source shall be in equilibrium with its decay products, and that it shall not absorb its own radiation.

* It should be noted that the primary beta rays of the radium produce secondary gamma rays in traversing matter. Since the efficiency of transformation of beta-ray energy into electromagnetic energy depends on the atomic number of the bombarded material, the strictest definition of the source would require a limitation on the amount and nature of the material traversed by the primary beta rays. There does not, however, appear to be any evidence of the practical importance of this factor with present techniques and the present level of accuracy of measurement.

* Read at the Twenty-fourth Annual Meeting, American Radium Society, St. Louis, Mo., May 15–16, 1939.
† Assistant Biophysicist, National Cancer Institute, National Institute of Health, U. S. Public Health Service.

It is further specified that the radioactive material be surrounded by a uniform filter of platinum 0.5 mm. in thickness which shall be regarded as a part of the source. These conditions cannot, of course, be met in practice and certain corrections must be made in estimating the specific effective gamma-ray intensity.

By *thimble chamber method* is here meant the use of a thimble chamber for the measurement of radiation in roentgens without any dependence upon the "standard" open air chamber which was implied in the previous definition of the roentgen. An *ideal thimble chamber* must sharply define a body of air from which all ionization can be collected and measured. This body of air is termed the *ionized volume*. It must also comply with the following conditions:

Wall Material Condition. The ionized volume must be completely surrounded by solid walls which react to those radiations which may be measured in roentgens in a way identical to the way in which air reacts to such radiations. In other words, identical processes are supposed to occur on a dimensional scale inversely proportional to the specific gravity of the wall material relative to that of the air in the ionized volume.

Wall Thickness Condition. The thickness of the wall must be as great as the maximum range in the wall of those ionizing particles which are generated within the wall.*

Attenuation Condition. There must be no attenuation of the radiation in the wall of the thimble chamber.

It is generally recognized that if such an ideal chamber were completely bathed in a beam of parallel radiation, a condition of exact compensation would prevail within the chamber. The compensation ratio may be defined as the ratio of the ionization in the limited volume of the chamber to the ionization which would be produced in free air by the ionizing particles generated in the same limited air volume of the chamber. The intensity in roentgens per second would then be given merely by the saturation ionization current in e.s.u. per 0.001293 gram of air in the chamber volume. With an actual chamber, therefore, the intensity can be determined if the compensation ratio, volume, air density and ionization can be determined.

Obviously the wall material and attenuation conditions above cannot be fulfilled in practice. It is generally supposed, however, that if a fourth condition is applied, and the actual wall material is suitably chosen, an approximation to the ideal chamber can be obtained which is practical for use with filtered gamma rays, and extremely hard roentgen radiations. The fourth condition is as follows:

Cavity Size Condition. The linear dimensions of the ionized volume must be small in comparison with the range in air of the ionizing particles.

In theoretical discussions of the thimble chamber method it has been customary to impose still another condition which may be stated as follows:

Parallelism Condition. The distance from the chamber to the source of any measured radiation must be great in comparison to the external† dimensions of the chamber.

The literature on the thimble chamber method is now quite voluminous and a complete list of references will not be attempted here. The literature is well covered in papers presented at the last International Congress of Radiology, most of which have since been published in the radiological journals. A few references will be given to illustrate methods of dealing with the differences between a real and an ideal thimble chamber. Mayneord and Roberts[10] have shown that a fairly satisfactory correction for attenuation in the wall of the thimble chamber may be made in certain cases by the use of the true absorption coefficient as calculated from the Klein-Nishina formula. In case of doubt one may apply successive additional thicknesses to the chamber wall and extrapolate back to zero wall thickness,

* Under certain special experimental conditions the following requirement might have to take precedence: the thickness of the wall must suffice to exclude from the ionized volume all ionizing particles generated at points external to the thimble chamber wall.

† Comparison with *internal* dimensions would leave open the possibility of over-compensation in an infinitesimal ionized volume. See references 1 and 9.

as they did. The curve so obtained will also serve to tell whether or not the wall thickness condition is satisfied under the particular experimental conditions used. Gray[4] has shown that conformity with the cavity size condition may be tested by reducing the air pressure in the ionized volume. If the ionization is directly proportional to the pressure, it may be assumed that the linear dimensions of the ionized volume are sufficiently small in comparison with the range in air of the ionizing particles. With regard to this test, Gray has made a somewhat more comprehensive statement concerning which we shall have something to say later. Laurence[8] has made theoretical calculations of the ratio of the ionization in a real thimble chamber to that in one with truly air-equivalent wall, as a function of chemical composition of the real wall and of spectral intensity distribution. These calculations are applicable to hard radiations if all the other thimble chamber conditions are sufficiently satisfied.

With regard to the degree to which the parallelism condition must be satisfied in practice, less is known. If the cavity size condition is satisfied it is certain that nearly 100 per cent of the ionization is due to particles generated in the walls of the chamber. For this reason it seems to be generally supposed that the importance of divergence of the radiation (departure from the parallelism condition) may be judged in terms of the variation of the intensity throughout the walls of the chamber.

In the case of the hard radiations with which we are here concerned, there is good reason to believe that the majority of the ionizing electrons originate in that half of the chamber wall which is closest to the source. One finds in the literature references, based on this reasoning, to a shift of the effective center of the thimble chamber away from the geometrical center, and toward the source. The specific effective intensity from a point source is ordinarily obtained by multiplying the ionization per unit volume in the thimble chamber by the square of the distance from source to thimble chamber. It is thus supposed that if the average distance from source to ionized volume is used, the intensity will be *over-estimated* in proportion as the square of the average distance exceeds the average square of the distance to part of the wall nearer to the source. Although not quantitative, this statement does provide a criterion in terms of which the influence of divergence may be roughly estimated. While there is on record some evidence that this criterion is satisfactory in certain cases, we shall now show that in one case it is very questionable.

Let us return for a moment to the previous experiment[1] with spherical bakelite shells surrounding a small source of gamma rays. In that experiment all the conditions of applicability of the thimble chamber method except the parallelism condition appeared to be fulfilled as completely as is practicable. Can the discrepancy between that result and those obtained with more conventional arrangements be ascribed to an effective distance less than the average distance from source to ionized volume? The formula used for the calculation of the specific effective intensity was

$$\frac{I}{4\pi t} \tag{1}$$

where I was the ionization current per gram of radium and t was the radial thickness of the spherical air shell constituting the ionized volume. Without discussing the way in which (1) was derived it will now be expressed in the form:

$$d^2I/V \tag{2}$$

used when the specific intensity is estimated from measurements made with a conventional thimble chamber of volume V situated at an effective distance d from the source. If r was the inner radius of the spherical air shell, we have

$$\frac{d^2I}{V}=\frac{d^2I}{\frac{4\pi}{3}\{(r+t)^3-r^3\}}=\frac{I}{4\pi t}\times\frac{d^2}{r^2+rt+\frac{t^2}{3}}. \tag{3}$$

From the point of view of the conventional arrangement it was thus implicitly assumed that the effective distance from source to point of measurement was given by

$$d^2=r^2+tr+\frac{t^2}{3}$$

which is slightly *greater* than the average distance $r+\frac{1}{2}t$. If then any shift of the effective center must be toward the source we reach the interesting conclusion that the formula (1) should give a result slightly in excess of the true value, rather than a considerable deficit. As a matter of fact under the conditions of that experiment ($r=0.935$ cm.; $t=0.22$ cm.) the factor

$$\frac{d^2}{r^2+rt+\frac{t^2}{3}}$$

in expression (3) could counterbalance a deficit of 20 per cent in $\frac{1}{4}\pi t$ only if the effective distance d of the chamber were set almost equal to the outer radius of the ionized air shell. Thus we must conclude either, first, that the intensity, as measured by the thimble chamber method, does not obey the inverse square law of variation with distance from a point source, or second, that this criterion for the influence of divergence of radiation upon thimble chamber readings is not generally valid.

So far as we are aware there has been advanced only one other criterion in terms of which the influence of divergence may be judged. The thimble chamber method is basically dependent upon Gray's principle[3,4,5,6] which states the relationship between the ionization in a small cavity and the absorption of energy in the walls of the cavity when certain conditions are satisfied. The practical conditions of applicability of the thimble chamber method should be identical with the conditions under which Gray's principle holds true. In his early mathematical discussion Gray[3] has postulated "a small air cavity in an extended solid medium traversed by penetrating radiation in any arbitrary manner, the variations in intensity of the radiation in distances comparable with the dimensions of the cavity being negligible." We have not been able to find an equivalent restriction stated in any of his later publications on the subject. In his discussion of the reduced pressure test it is stated that "The equation [the mathematical statement of the principle] may therefore be considered valid in any circumstances in which the ionization remains proportional to the pressure as the pressure is reduced below normal value."[4] Couched in such terms it would seem that this test should provide a criterion by which the influence of divergence, as well as other factors, might be judged. At the time of the previous experiment[1] with the spherical air shell, Gray's earlier restriction had not been noted. Failure of an (unpublished) reduced pressure test to reveal the slightest indication of non-proportionality made that result particularly puzzling, for acceptance of the criterion led to the conclusion that the dosage rate, as obtained by the thimble chamber method, could not obey the inverse square law of variation with distance from a point source. In fairness to Gray it should be stated at this juncture that we shall later show the influence of divergence of radiation by means of the reduced pressure test. Unfortunately this effect is manifested experimentally only when the dimensions of the ionized volume are not negligible in comparison with the range of the electrons. Thus although the criterion is theoretically correct, it cannot be accepted as a practical index for this purpose.

3. MATHEMATICAL ANALYSIS

During the course of a theoretical treatment of the influence of geometrical factors on the measurement of radiation in roentgens, Lauritsen[9] has discussed the experimental arrangement with which we are here concerned. He reached the conclusion that if the wall material and wall thickness conditions were satisfied, 100 per cent compensation should obtain in a spherical air shell with point source at center. In other

words, the formula $I/4\pi t$ should, with proper allowance for attenuation, give the correct value for the specific effective intensity. Lauritsen's conclusion depends upon a number of simplifying assumptions among which will be found the following: If the path of an electron makes an angle θ with the ray from which it is ejected, and if x is the path length of the electron in the air shell, then $x=t/\cos\theta$, where t is the radial thickness of the air shell. This approximation is satisfactory only when the ratio of t to the radius of the shell is vanishingly small. Using assumptions similar to those of Lauritsen concerning the behavior of the ionizing electrons, we shall now derive a somewhat more exact expression for the ionization in *finite* air shells.

Suppose that the specific effective gamma-ray intensity of radium is attributable to N idealized rays each of which, in spite of complete lack of attenuation, ejects continuously k electrons per second per centimeter of ray path in air of density 0.001293 gm/cc. Suppose that each of these electrons travels in a straight line making an angle θ with the ray by which the electron was ejected. Suppose that each electron liberates by uniform ionization i electrostatic units of charge of each sign per centimeter of path in air of density 0.001293 gm/cc. and that the total path length of the electron in such air is R centimeters. Then the specific effective gamma-ray intensity of radium is

$$E=60\,NikR/4\pi \text{ roentgen/min.}$$

Suppose that a spherical air shell of inner radius r centimeters and radial thickness t centimeters is defined by solid spherical shells complying with the wall thickness and the attenuation conditions of the thimble chamber method, and that the specific source of idealized gamma rays is placed at the center of the combination. Suppose that in this wall material each ray ejects k' electrons per second per centimeter of ray path and that the stopping power of the material is s relative to air of density 0.001293 gm/cc. Suppose that the specific gravity of the air in the air shell is p relative to air of density 0.001293 gm/cc. Then if the inner solid shell requires no support the electrons ejected by all rays will give identical ionization. Further, the total ionization due to the electrons from one ray will be the same as if, as depicted in Figure 1, all were

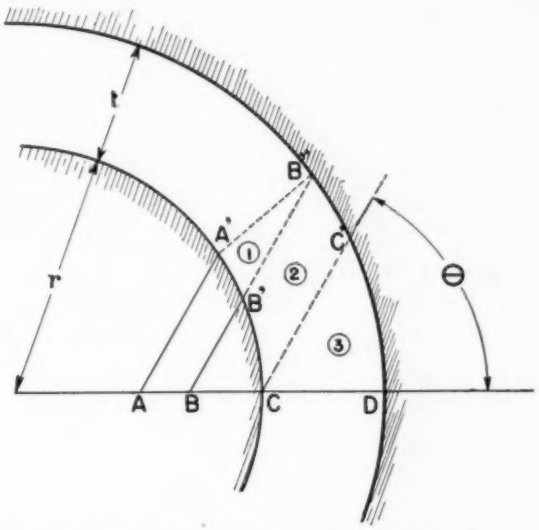


Fig. 1. Ionization in a spherical air shell.

ejected in a plane and on one side of the ray. Let the point A be at such a depth in the inner solid shell that electrons from A can just reach the air shell. Let the point B be so situated that electrons from B can just cross the air shell. Then:

$$R=sAA'=sBB'+pB'B''. \qquad (4)$$

The ionized area $A'B''C'DCB'A'$ in Figure 1 is divided up into three zones in each of which the ionization is proportional to the rate of passage of electrons and to the average path in air. The following table and equations give these quantities for each zone. The values given for average paths are approximations except in the case of zone 3.

Zone	*Electrons/sec.*	*Average path*
1	$k'AB$	$\frac{1}{2}x$
2	$k'BC$	x
3	pkt	$\bar{x}$

$$x=CC'=\left\{(r\cos\theta)^2+2rt+t^2\right\}^{1/2}-r\cos\theta$$

$$\bar{x}=\frac{(r+t)^2}{2t\sin\theta}\left\{\theta-\sin^{-1}\left(\frac{r\sin\theta}{r+t}\right)\right\}-\frac{xr}{2t}$$

The diagram is drawn much out of proportion in order that the different zones may be more easily seen. As a further approximation it is assumed that the range of the electrons in the solid is short enough in comparison with r so that we may write

$$\frac{AC}{AA'}=\frac{BC}{BB'}=\cos\theta. \qquad (5)$$

With the aid of equations (4) and (5) the number of electrons passing per second through zones 1 and 2 may be evaluated. If I is the total ionization current in electrostatic units due to all N rays, it follows that

$$E=\frac{\dfrac{60I}{4\pi tpg}}{P\left\{1+\dfrac{p}{R}\left(\dfrac{\bar{x}}{gP}-\dfrac{x}{2}\right)\right\}} \text{ roentgen/min.} \qquad (6)$$

in which, for abbreviation

$$P=x\cos\theta/t$$
$$=\left[\left\{(r\cos\theta/t)^2+2r/t+1\right\}^{1/2}-r\cos\theta/t\right]\cos\theta$$
$$g=k'/ks.$$

The factor g is what is required to convert the observed ionization to that which would have occurred had the chamber walls been truly air-equivalent. g may be considered as known or determinable. P is a function of (r/t) and $\cos\theta$ which increases continuously from $\cos\theta$ to 1 as (r/t) increases from zero to infinity.

A lower limit to t, and hence an upper limit to r/t, is set by practical considerations of construction and measurement. Going toward the other extreme, the analysis applies only to cases for which the electron range is less than x, and a lower limit to r is set by the wall thickness condition.

In the previous experiment[1] it was found that, within experimental error, the ionization was proportional to pressure. The influence of the wall material was also taken into account. In testing the possibility of explaining the previous result by means of formula (6) it is sufficient for the moment to write

$$\frac{60I}{4\pi t}\div E=P.$$

Putting in P the values 0.935 and 0.22 for r and t respectively, it is found that a not unreasonable θ value of about 60° gives $P=0.8$, which is required to account for the previous result. Using these values it is found that the bracketed quantity in formula (6) is about $1+0.04p/R$. Thus even if the value of R were as little as 20 cm. this factor would change by only ⅛ of 1 per cent as the air pressure is reduced from normal to zero. The analysis predicts that the predominating influence of divergence should appear in the value of P which is independent of pressure. It follows that Gray's criterion, though supported by this analysis, can scarcely be relied upon to provide a quantitative index of the effective divergence of the radiation passing through a thimble chamber.

Anticipating further experimental support for formula (6) it is convenient at this point to conclude the discussion of the parallelism condition. The question arises: Could an analysis such as the preceding yield a quantitative criterion in the case of quite different arrangements of source and ionized volume? The treatment given here has been greatly facilitated by the high degree of symmetry possessed by the experimental arrangement, considered as requiring no support for the inner solid shell. The application of such an analysis to less symmetrical arrangements is fraught with serious mathematical difficulties and it appears to us at the present time that the answer must be in the negative. Therefore we can only emphasize that in any thimble chamber measurement in which the parallelism condition is not well satisfied the closest experimental attention should be directed to the consequences of a variation in the size and shape of the ionized volume.

From here on we shall be mainly concerned with the estimation of the specific effective gamma-ray intensity of radium. It is easily shown that if in formula (6) the value of θ must be about 60° it would be difficult to construct spherical shells such that the factor P is nearly unity. Thus the quantity $60I/4\pi tpg$, which may be con-

sidered as observable, must differ appreciably from the quantity E which is to be ascertained. It is then necessary to inquire whether or not it is possible to choose a value of θ such that the right hand side of equation (6) will remain constant as geometrical conditions (r/t) are varied as much as is practicable. At low values of r/t the bracketed term in the denominator will have some influence on the result. As soon as an approximate value of θ has been obtained, the coefficient of $1/R$ in this term can be calculated with sufficient accuracy to allow a determination of R by means of a reduced pressure experiment. Provided this determination is made for the minimum value of r/t used, the bracketed quantity involving R can then be calculated with sufficient precision for all other experimental conditions, for which its quantitative effect will be less. It is then possible to make further small variations in θ in order to see whether the values calculated for the right hand side of equation (6) may be made more nearly equal to one another.

The calculation of P for different values of θ is somewhat laborious. Since the derivative of P with respect to θ can be calculated with little additional labor, the following procedure was found helpful. Supposing that all other corrections have been made, equation (6) may be written in the form:

$$y=\frac{60I}{4\pi tpg\left\{1+\frac{p}{R}\left(\frac{\bar{x}}{gP}-\frac{x}{2}\right)\right\}}=EP.$$

If E_1 and ϕ are approximate values of E and θ such that

$$E=E_1(1+q) \qquad \theta=\phi+h$$

the above equation may be written

$$\frac{y}{E_1P(\phi)}-1=q+\frac{h}{P(\phi)}\frac{\partial P(\phi)}{\partial\phi} \qquad (7)$$

in which terms in h^2, qh, etc., are neglected. Equation (7) is linear in known quantities and thus readily solvable for q and h by a least squares method. In order to make some allowance for the fact that some of the measurements could be made with greater precision than others, certain observations have been weighted more heavily than others in making the least squares analysis. Noting that $\partial P(\phi)/\partial\phi$ tends to zero as t/r tends to zero, it is seen that through q we determine the value of E which obtains at zero air shell thickness. The procedure is therefore equivalent to an objective extrapolation of observed values to an experimentally unattainable limit. The uncertainty in q can be evaluated by statistical methods, and this gives the uncertainty in the effective intensity which is attributable to a certain group of random experimental errors which will be considered later.

4. EXPERIMENTAL

The arrangement of the spherical shells constituting the walls of the ionization chambers used in this experiment is shown in Figure 2. The various combinations of shells have been divided into two groups designated as S (small) and L (large). Figure 2 shows the arrangement of a small shell combination approximately to scale. Except for the fact that air intervened between the source and the inner solid shell, the arrangement was essentially the same for the L group. The shells were constructed of hemispherical sections formed by pressing lucite into steel molds prepared with the aid of bearing balls.* To one edge of each shell was attached a lucite rim, both edges were then machined, and one-half shell in each case was provided with a stem so machined that a concentric assembly should result from mounting in the holder shown in Figure 2. In Table 1 is given for each shell combination the values of r, the outer radius of the inner solid shell; t, the radial thickness of the ionized air volume; the ratio of r/t required in the calculation of the function P.

The radii of the outer lucite shells were determined from the weight of fluid required to fill them—mercury for the S, water for the L shells. The radius of the

* We wish to acknowledge the courtesy of the E. I. duPont de Nemours Company in forming these shells.

single inner S shell was measured both by micrometer and pycnometrically, using mercury. The two results agreed within an experimental error which corresponded to a difference of 1 per cent in the smallest air shell spacing. Since the micrometer measurements had revealed a slight departure from true spherical shape, the pycnometric result was considered more reliable, and was adopted. On account of the high surface tension of mercury, it was not considered that much reliance could be placed on a check measurement by weight of mercury required to fill the air shell space. This was done with water in the L shells, and with satisfying results. The largest disagreement between micrometer and weighing methods was 0.2 per cent of the air shell spacing.

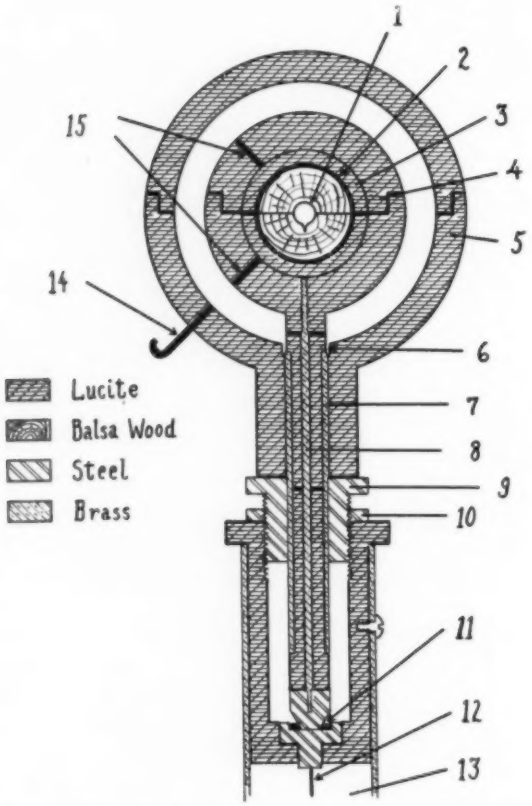


FIG. 2. Details of experimental setup. *1*, radon bulb; *2*, 0.533 mm. platinum filter; *3*, centering holder for filter; *4*, inner solid shell, graphited inside, outside down to the stem, and on edges of the hemispherical parts; *5*, outer solid shell, graphited on equatorial edges and on the inside down to the edge of *6*, a channel provided to ensure that any electrical surface leakage will go to *7*, a guard cylinder, connected to ground through *9*. *8*, The lead from the inner electrode; *9*, a spacing bushing by means of which the outer shell can be raised or lowered with respect to the inner assembly; *10*, locknut; *11*, mercury pool to ensure good contact; *12*, lead to ionization measuring apparatus; *13*, paraffin filling; *14*, aluminum wire making contact with inner surface of outer shell; *15*, graphite plugs to ensure good conductivity between inner and outer surfaces of *4*.

TABLE I

DIMENSIONS OF IONIZATION CHAMBERS

Shells	r cm.	t cm.	r/t
S_1	0.9841	0.0395	24.91
S_2	0.9841	0.1109	8.874
S_3	0.9841	0.2017	4.879
S_4	0.9841	0.2881	3.416
L_{11}	1.257	0.931	1.350
L_{22}	2.543	0.940	2.705
L_{33}	3.800	0.913	4.162
L_{31}	1.257	3.456	0.3637

Those shell surfaces which were to conduct electricity were coated with a very thin layer of aquadag. Conductivity was tested directly in some cases, and always after assembly by saturation of the ionization current. Potential was applied to the outer electrode. The ionization current was measured by a modified Townsend compensation method using an *FP*-54 pliotron as a detector. The apparatus for the production of the compensating current was developed by two of us (G. F. and L. M.) at this laboratory, and will be described elsewhere. The relative values of current were obtained in terms of the reading on a multi-range precision voltmeter. Since radon was used as a source of gamma rays and readings were taken at various times during the decay of the source, and since the ionization currents from different shell combinations differed widely, the different scales on the voltmeter were used more or less at random. It is therefore assumed that no systematic error is involved on account of errors in calibration of the voltmeter. These readings were placed on an absolute current scale by standardizing the voltme-

ter reading in terms of the current from an ionization chamber containing radium; the current from which had been previously determined within an error estimated to be less than 0.60 per cent. The error in relative values of voltmeter readings is known to be considerably lower than this.

In all cases measurements were taken with both positive and negative polarity applied to the ionization chambers. For the smallest chambers, these readings differed by a factor of nearly two on account of the electron current.[1] The average of the positive and negative polarity readings gave the ionization current due to the gamma radiation from the source plus (in some cases) a very small current due presumably to radioactive contamination of the chamber. Any spurious current due to contamination was measured with the gamma-ray source removed.

Correction for reduction of the ionization current on account of the presence of a supporting stem on the inner solid shell was made in the following way. For the S shells the observed ionization current was divided by $(4\pi-\Omega)$ instead of 4π. Ω was the solid angle subtended at the source by the cross-sectional area of the stem at a distance of $r+\frac{1}{2}t$. For the L shells the observed current was increased by a fraction v/V where v was the calculated volume of the stem and V the ionized volume. The values for these corrections, expressed as percentages, are given in Table II.

TABLE II
STEM CORRECTIONS
(per cent)

S_1	1.39	L_{11}	0.453
S_2	1.31	L_{22}	0.74
S_3	1.2	L_{33}	0.33
S_4	1.1	L_{31}	0.065

Tests were made to evaluate the magnitude of errors in the ionization current to be expected on account of eccentricity of the chambers. It was found that if the inner shell was displaced by 50 per cent of t, the ionization reading was reduced by only 0.4 per cent in the case of the L_{33} chamber, while a displacement of the same amount caused a change of 2.7 per cent in the case of L_{11}. On account of the method of construction and mounting of the shells, the effect of eccentricity must be entirely negligible for the L chambers. For the S chambers the effect may be appreciable, and for this reason the measurements obtained with them could not be considered subject to equally rigorous geometrical conditions.

Experiments were performed with three gamma-ray sources. Each was a small glass bulb containing radon. Measurements were taken with each source in the S shells. At the end of the experiment with the first source, it was decided that the channel designated as 6 in Figure 2 was unnecessarily large, making it difficult to determine accurately the mean thickness of the air shells in the cases of S_1 and S_3. Results of this experiment were rejected and these shells were reconstructed. The values given in Table I apply to the reconstructed shells. Experiment II was performed with a radon bulb of about 4 mm. inner diameter mainly for measurements with the L shells. This source was a little large and rather weak for most accurate measurements with the S shells, especially S_1. For Experiment III a radon bulb of about 2 mm. inner diameter was used. Assuming that in both cases the bulbs were spherical and that the active material was uniformly distributed on the inner surface, corrections for departure from a point source were calculated. The possibility of error on account of failure to center the bulb accurately has also been considered in the following way. An estimate was made of the maximum distance which the bulb might have been off center without detection. It was then assumed that the bulb was actually off center by half this amount. Table III gives the estimated percentage excess in the ionization current for the various shell combinations on account of these factors.

The radon bulbs, enclosed in the same 0.533 mm. platinum shell as in the experiment, were calibrated against the Memorial

TABLE III

CORRECTION FOR POSITION AND SIZE OF BULB

Shells	Per cent	
	Experiment II	Experiment III
S	0.80	0.30
L_{11} and L_{21}	0.68	
L_{22}	0.17	
L_{23}	0.07	

Hospital 5 mg. radium needle, all customary precautions being taken. In the case of the Experiment II source the comparison was made when about 20 mc. of radon was present. For this reason, as well as because the source was rather large, less weight is given to Experiment II than to Experiment III, the calibrations for which were performed when the radon content was about equal to the 5 mg. standard of comparison. Tables based on a half-life of 3.823 days were used in calculating the radon decay. The average standard error of these calibrations was 0.35 per cent. The outer diameter of the spherical platinum shell used as filter with the radon bulbs was 9.17 mm. With bulbs of the size used in these experiments, the effective thickness may be considered equal to the actual thickness of the platinum shell. The Memorial Hospital needle was a platinum cylinder of 1.13 mm. outer diameter, 0.73 mm. inner diameter, and external length 13.93 mm., with the salt tightly packed inside. The effective thickness of the platinum in this needle does not come into consideration, since it was used only as in intermediate standard. This needle was calibrated in the same way against the Radium Chemical Company's 5.02 mg. radium cell, 0.2 mm. platinum filter, National Bureau of Standards' certificate No. 3695. A 0.3 mm. cylinder of platinum was slipped over this standard to give the proper 0.5 mm. platinum filtration. The outer diameter and length of this cylindrical cell were then 1.6 mm. and 11.5 mm. respectively. Due to the fact that the effective thickness was greater than the actual 0.5 mm. thickness of filter, it was estimated, using the data of Kaye,[7] that the actual radon content of the bulbs was 0.2 per cent in excess of the amount given by the calibration ratio. The standard error of the calibration of the Memorial Hospital needle in terms of the Radium Chemical Company's cell was 0.20 per cent. The error of the National Bureau of Standards' calibration is given as 0.70 per cent, so that the error in estimation of the radium equivalent of the sources used was 0.8 per cent.

The spherical platinum shell used as filter in this experiment had been constructed with generous dimensions in order to avoid the problem of estimating different effective thicknesses which would obtain when various sources were used. By so doing, the possibility of an error on account of a different phenomenon is introduced. In defining a spherical gamma-ray source, we have required that both the filter and radioactive material behave as a point source. Since the radius of the platinum shell is not small in comparison to the radius of the ionized air shells, especially in the case of the S chambers, there is the possibility that the ionization due to the radiation scattered from the filter may exceed appreciably the ionization which would obtain if the shell were much smaller. To evaluate the error on this account, it is sufficient to estimate the extent of departure from the inverse square law on account of the radiation scattered by the filter. If it is assumed that the true absorption coefficient of air is constant for the wave lengths under consideration, then the ionization due only to radiation scattered from a thin spherical filter can be shown* to be proportional to

$$\frac{1}{r}\int_0^{\pi/2} \frac{I(\theta)\sin\theta\, d\theta}{(r^2-a^2\sin^2\theta)^{1/2}} = \frac{1}{r^2}\int_0^{\pi/2} I(\theta)\cdot\sin\theta\, d\theta\left[1+\frac{a^2}{2r^2}\sin^2\theta+\cdots\right]$$

where r is the distance from source to point of measurement

a is the radius of the filter

$I(\theta)$ is the intensity of scattering per unit solid angle at an angle θ from the normal to the filter.

* Acknowledgment is made to Dr. U. Fano for this formula.

In the case of Compton scattering the proportional departure from the inverse square law may be estimated with sufficient accuracy by a simple application of the Klein-Nishina formula for two strong gamma-ray lines near the ends of the spectrum. For the lower frequency line there will be a small addition due to fluorescent radiation, which may be considered to be emitted isotropically. For the S group of shells, for which $a/r=0.44$, the following percentages were obtained:

	Gamma-ray line	
	354 kv.	1778 kv.
	(per cent)	
Compton scattering from filter:		
excess over $1/r^2$ law	5.1	2.4
intensity relative to primary rays	6.2	2
Fluorescent radiation from filter:		
excess over $1/r^2$ law	6.5	6.5
intensity relative to primary rays	1.6	0.03
Net excess in total radiation	0.42	0.05
Relative intensity of lines	1	3
Average excess for spectrum	0.14	

A number of assumptions involved in the calculations enhance the above figures, and it is doubtful if the total error is over 0.1 per cent. This correction will decrease according to the inverse square law with the radius of the air shell so that it becomes extremely small for the L group of chambers.

In the calibration of the radon bulbs a certain amount of lucite was present. In order to correct for attenuation it was necessary only to take into account that amount of lucite which was present in the experiment but not present in the calibration. Using the Klein-Nishina formula, the true absorption coefficient in lucite was calculated. The following data were used:

Empirical formula for lucite: $C_5H_8O_2$
Specific gravity: 1.19; $\sigma_a=0.90\times10^{-25}$ per electron
Correction for absorption of lucite 0.35% per mm.
Excess lucite: S shells 3.3 mm.
L shells 4.4 mm.

This procedure was justified by the following test. The ionization in the L_{33} air shell was measured. The interior of the inner lucite shell was then filled with distilled water, and the ionization again measured. The radial thickness of the absorbing shell of water was about 2.5 cm. It was found that the ionization was decreased 0.297 per cent/mm. of water. Using $\sigma_a=0.90\times10^{-25}$ per electron, the absorption by water of recoil electron energy is 0.303 per cent/mm. For the range of thickness of lucite used in this experiment, it is seen that the use of σ_a only should not introduce errors as large as 0.1 per cent.

A previous experiment[1] at this laboratory has shown that 3.7 mm. of bakelite, of specific gravity 1.34 when placed around a small source is sufficient to comply with the wall thickness condition. This is equivalent to 4.2 mm. lucite. In the S shells the lucite thickness was about 5.2 mm. and for the L shells about 1.1 mm. more was used.

In order to take account of the fact that lucite is not air-equivalent, the data provided by Laurence's calculations have been used, placing g of formula (6) equal to his B which, for lucite, is 0.9556. Since his calculations were based on the assumption that radiation passing through the material is parallel, this procedure is not strictly correct. Laurence states, however, that the influence of divergence of radiation on his correction factors would be small.*

5. RESULTS

After the application of the various corrections considered in the preceding section, the following data given in Table IV were obtained. This table gives the values which are to be substituted for $60I/4\pi tpg$ in formula (6). The results for the various shells have been arranged in the order of decreasing r/t.

To avoid unnecessary detail, we shall merely state at this juncture that the values given in this table approximately satisfy formula (6) if θ is chosen equal to 60°. This value of θ is therefore satisfactory for

* The error in g can be shown to be of the order of $(1-B)(R/sr)^2$, where R, s, r have the same meaning as before. This is much smaller than other errors introduced by approximations in our mathematical analysis.

use in the evaluation of the bracketed factor in the denominator.

TABLE IV

Shells	r/t	$\frac{60I}{4\pi tpg}$ Apparent roentgens/min /gm. at 1 cm. Experiment II	Experiment III
S_1	24.91	136.7	136.6
S_2	8.874	126.9	127.7
S_3	4.879	119.0	120.6
L_{33}	4.162	119.9	—
S_4	3.416	114.2	115.5
L_{22}	2.705	113.6	—
L_{11}	1.350	102.6	—
L_{31}	0.3637	95.2	—

By means of an experiment in which the air pressure in the L_{31} shell combination was varied from normal to zero it was found* that:

$$\frac{1}{R}\left\{\frac{\bar{x}}{gP}-\frac{x}{2}\right\}=0.1003\pm0.0035.$$

We pause here to emphasize that the experiment demands the influence of a geometrical factor to account for the size of the result. The maximum effect which could appear with a lucite chamber in a parallel beam of radiation would be

$$\frac{1}{g}-1=\frac{1}{0.9556}-1=0.0465.$$

The difference between this amount and the observed 10 per cent is far in excess of the experimental error.

Using θ equal to 60° it was found that R was equal to 22.4 cm. It would not be expected that the value so derived would agree with the arithmetical average range calculated on the basis of number and energy of electrons ejected by the gamma-ray spectrum. According to the analysis the greatest contribution to the observed effect would be made by electrons of small range and large θ, and when this is taken into account it is seen that the particular average obtained by this procedure is not unreasonable. Table v gives the corrections to be applied to the other shell combinations as calculated with this value for the range.

TABLE V

Shells	$1+\frac{1}{R}\left(\frac{\bar{x}}{gP}-\frac{x}{2}\right)$
S_1	1.000
S_2	1.001
S_3	1.002
L_{33}	1.012
S_4	1.003
L_{22}	1.016
L_{11}	1.020
L_{31}	1.100

Table VI gives the values which according to the mathematical analysis should represent EP, also the values of E calculated when θ equal to 57° 25′ is placed in P.

TABLE VI

Shells	Experiment II			Experiment III		
	EP	Weight	E	EP	Weight	E
S_1	136.7	0.1	142.9	136.6	2	142.8
S_2	126.8	1	141.0	127.6	4	141.9
S_3	118.8	2	140.0	120.3	8	141.9
L_{33}	118.5	1	142.3	—	—	—
S_4	113.8	3	140.0	115.2	12	141.7
L_{22}	111.8	0.5	141.8	—	—	—
L_{11}	100.6	1	140.5	—	—	—
L_{31}	86.4	1	141.7	—	—	—

The relative weights in Table VI have been assigned within each experiment mainly on the basis of the accuracy with which the air shell spacings were considered to be known. Experiment III has been weighted four times as heavily as Experiment II as an arbitrary evaluation of the importance of certain factors which have been previously mentioned. In order to obtain from the data of both experiments a

* For this purpose formula (6) is rewritten in the form

$$\frac{I}{p}=A+A\frac{1}{R}\left(\frac{\bar{x}}{gP}-\frac{x}{2}\right)p$$

which is linear in I/p and p. A is a constant for the reduced pressure experiment.

single extrapolated value for the specific effective intensity by the procedure outlined in connection with equation (7) the following method was used. Taking account of the weights it was found that the results of Experiment III exceeded the corresponding S shell values of Experiment II by about 1.17 per cent. The total weights assigned to the experiments are II:III::10:26. All Experiment II values were therefore increased by $26/36 \times 1.17 = 0.85$ per cent and all Experiment III values decreased by $10/36 \times 1.17 = 0.32$ per cent. Using the E values so obtained, a least squares analysis gave

$$E = 141.06 \pm 0.88 \text{ roentgen/min/gm. at 1 cm.}$$
$$(\pm 0.63\%)$$

The figure 0.88 includes, of course, the uncertainty in E due to the uncertainty in θ, for which a value

$$\theta = 57^\circ\ 23' \pm 14'$$
$$(\pm 0.41\%)$$

was obtained. The uncertainty in E given above may be assumed to include also the effect on E due to a number of other errors the most important of which are:

random errors in the measurement of ionization current;

random errors in the measurement of the geometrical constants of the chambers.

There must then be added those errors which affect the data as a whole:

error in absolute measure of ionization current: 0.6 per cent;

error in radium equivalent of sources: 0.8 per cent.

The total error in the specific intensity as above derived is therefore ± 1.2 per cent. We shall add a certain amount to this error for reasons given in the discussion following.

6. DISCUSSION

If equation (7) is applied independently to the results obtained with the S chambers in Experiments II and III one obtains

II $E = 142.5 \pm 0.9$ roentgen/min/gm.
$\theta = 58^\circ\ 57' \pm 35'$

III $E = 142.8 \pm 0.4$ roentgen/min/gm.
$\theta = 58^\circ\ 4' \pm 14'$

These values do not differ significantly, but their averages

$$E = 142.8 \pm 0.4 \text{ roentgen/min/gm.}$$
$$\theta = 58^\circ\ 15' \pm 14'$$

obtained by weighting as before, differ from the values obtained from the data as a whole by amounts which may be significant. Due to the fact that the S chambers comply more closely with certain of the thimble chamber conditions, there is a temptation to exclude the L chambers from consideration and accept this as the best value. On the other hand, for the L shells the geometrical constants may be better known, the symmetry conditions may be better fulfilled and the departure from a punctiform source is certainly of less importance. The results obtained with the S chambers suffer from a certain weakness in that all had the same inner shell. Since the air shell thickness t was obtained from the difference between the inner and outer radii, any error in the determination of the inner radius would cause a systematic error in the results. For example, if there were an error of 0.6 per cent in t for S_1 from this cause, the error in t for S_4 would be only 0.1 per cent. The discordant trend of these data could thus be easily explained. It has been noted that the determination of the radius of the inner shell by two different methods gave results differing enough to alter t for S_1 by 1.0 per cent. Although it was considered that one of the methods of measurement was much more reliable than the other, the possibility of a systematic error in the S shell data cannot be excluded. From this point of view it would appear that an injudicious weight had been assigned to the S, relative to the L, data. We frankly admit that the weights might better have been disposed somewhat otherwise, but lacking any factual basis for alteration we prefer to maintain the original assignment.

We wish to emphasize at this point that the ionization chambers were originally designed for the purpose of investigating the influence of geometrical factors on the ionization caused in spherical air shells by a gamma-ray source placed at the center. They have served this purpose admirably. It is a matter for considerable surprise that formula (6), derived with such simplifying assumptions, should be able to account so well for the observations, and that so precise a value for the specific effective emission should be obtainable from these data. It would seem that with suitably designed chambers a considerably higher degree of precision should be attainable. In this connection it is in order to make a few remarks on certain points not hitherto mentioned.

It is well established that in an ordinary thimble chamber an appreciable portion of the ionization is attributable to electrons ejected by the radiation from the side walls of the chamber. In the spherical shell chamber with source at the center the support for the inner shell must act as a diminutive side wall. It is therefore not entirely correct to assume as we have done that the stem merely acts to suppress ionization in proportion to the volume occupied by the stem. It is very doubtful if the error on account of this procedure would add appreciably to the error which will finally be stated, but in an experiment aiming at higher precision this matter should receive attention.

In deriving formula (6) it has been assumed, neglecting curvature of the inner solid shell, that the maximum depth from which electrons can reach the air shell is proportional to the electron range in the solid. This is equivalent to the assumption that the range in the solid is small in comparison with r, the radius of the inner shell. Judging by the value of the range obtained by means of the reduced pressure test, this assumption is sufficiently accurate for the present purpose. However, the evaluation of the range was dependent upon the formula involving this assumption, and without a laborious extension of the analysis one cannot be certain that this conclusion is entirely valid. Invalidity of this conclusion should be evidenced by discontinuities in the present data where r is changed. The fact that the values obtained with the small chambers show a trend somewhat different from that of the data as a whole might be interpreted in this way. We believe it more likely that this difference in trend is attributable to certain errors of measurement discussed above, but in order to make some allowance for this possibility we shall arbitrarily add 0.8 per cent to the over-all error. The final value for the specific effective gamma-ray intensity of radium, as obtained by these experiments, is therefore

141.1 roentgen/min/gm. at 1 cm. distance, or

8.47 roentgen/milligram-hour at 1 cm. distance ± 2.0 per cent.

For purpose of comparison we present in Table VII the values obtained by Laurence[8] after applying his wall material corrections to a group of thimble chamber measurements. To these we have added the later experiment of Gray,[6] corrected in the same way.

TABLE VII

COMPARISON OF SOME THIMBLE CHAMBER MEASUREMENTS

Authority	Roentgen/mg-hr. at 1 cm.
Friedrich and Schulze	8.0
Murdoch and Stahel	8.4, 8.6
Mayneord and Roberts	8.5
Sievert	7.95
Grimmett and Read	8.65
Gray	8.5
Present authors	8.47

The agreement with some of these values is very good, and this is particularly satisfying in view of the considerable difference between the geometrical conditions of this experiment and the geometrical conditions used by the investigators whose values are cited here.

In closing the discussion we would like to make a few additional remarks concerning formula (6). It is known that the electrons liberated by gamma rays of radium are not all ejected at the same angle, that their

paths are not straight lines, that they do not ionize uniformly along their paths in air and that their ranges are not all the same, all of which assumptions were made in deriving the formula. Yet in spite of the extreme simplifications, the formula works very well. It would seem that there must be some good reason for this which must lie in the character of the processes which are actually occurring. The investigation of this problem would be rather difficult, but we believe that it merits attention.

7. SUMMARY

The desirability of unifying the basis of roentgen-ray and gamma-ray dosage has led physicists in many countries to undertake the measurement of gamma rays in roentgens.

Owing to practical difficulties, most experiments have been performed with thimble chambers and under very similar conditions; yet the results have not been satisfactorily consistent among themselves. This might indicate that perhaps there is some factor in this type of measurement which has not been thoroughly investigated. The numerical value of the specific effective gamma-ray intensity of radium should be the same irrespective of the method employed for its evaluation. Therefore, it is important that this quantity be determined by methods which are as different as possible. The standard air chamber method meets this requirement when compared to the thimble chamber method, but practical difficulties introduce considerable uncertainty in the final result.

A third method was introduced by us a few years ago, but the preliminary results obtained at that time differed by about 20 per cent from those obtained with the conventional thimble chamber method. In some respects the two methods are similar, but the geometrical conditions of source and ionized volume are very different. The source of radiation in our case is at the center of two concentric spherical shells and the ionized volume is defined by the air space between them.

The experiments herein described were undertaken to account for the discrepancy mentioned above. It has been found that after introducing certain theoretical considerations the new method becomes very well suited for the determination of the specific effective gamma-ray intensity of radium. The value obtained by this method is:

141.1 ($\pm 2\%$) roentgens per minute per gram at 1 cm. distance.

8.47 ($\pm 2\%$) roentgens per milligram hour at 1 cm. distance.

In view of the reasonable agreement among the results obtained by *different methods* of measurement, it may be concluded that the value of the specific effective gamma-ray intensity of radium is now known within the limits of accuracy stated.

REFERENCES

1. FAILLA, G., and MARINELLI, L. D. Measurement of the ionization produced in air by gamma rays. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 312–343.
2. FRIEDRICH, W., and SCHULZE, R. Neubestimmung der r-Einheit für Gammastrahlen. *Strahlentherapie*, 1935, *54*, 553–569.
3. GRAY, L. H. Absorption of penetrating radiation. *Proc. Roy. Soc. Lond., A*, 1928, *122*, 647.
4. GRAY, L. H. Ionisation method for the absolute measurement of gamma ray energy. *Proc. Roy. Soc. Lond.*, 1936, *156*, 578–596.
5. GRAY, L. H. Radiation dosimetry, Part I. *Brit. J. Radiol.*, 1937, *10*, 600–612.
6. GRAY, L. H. Radiation dosimetry, Part II. *Brit. J. Radiol.*, 1937, *10*, 721–742.
7. KAYE, G. W. C., ASTON, G. H., and PERRY, W. E. T. Wall-absorption and buckling strength of cylindrical radium containers. *Brit. J. Radiol.*, 1934, *7*, 540–557.
8. LAURENCE, G. C. Measurement of extra hard x-rays and gamma rays in roentgens. *Canad. J. Research*, 1937, *A*, *15*, 67–78.
   LAURENCE, G. C. Some problems of gamma-ray measurement in radiology. AM. J. ROENTGENAL. & RAD. THERAPY, 1938, *40*, 92–103.
9. LAURITSEN, C. C. Geometrical factors in the measurement of radiation in röntgens. *Brit. J. Radiol.*, 1938, *11*, 471–478.
10. MAYNEORD, W. V., and ROBERTS, J. E. Attempt at precision measurements of gamma rays. *Brit. J. Radiol.*, 1937, *10*, 365–386.
11. SIEVERT, R. M. Über die Anwendung der Kondensatorkammer für sowohl Röntgen-wie-γ-Strahlenmessungen; zugleich ein Beitrag zu den Vergleichen den biologischen Wirkungen dieser beiden Strahlenarten. *Acta radiol.*, 1934, *15*, 193–201.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR

Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.

Collaborating Editors: The Offices and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL.

Foreign Collaborators: A. BÉCLÈRE, M.D., PARIS, GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

THE AMERICAN ROENTGEN RAY SOCIETY

President: M. C. Sosman, Boston, Mass.; *President-Elect:* W. M. Doughty, Cincinnati, Ohio; *1st Vice-President:* G. E. Richards, Toronto, Ont.; *2nd Vice-President:* J. C. Dickinson, Tampa, Florida; *Secretary:* C. B. Peirce, Royal Victoria Hospital, Montreal, Que.; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J.; *Historian:* Percy Brown, 475 Commonwealth Ave., Boston, Mass.

Executive Council: M. C. Sosman, W. M. Doughty, G. E. Richards, J. C. Dickinson, C. B. Peirce, J. B. Edwards, Lawrence Reynolds, H. J. Walton, P. A. Bishop, U. V. Portmann, E. L. Jenkinson, J. W. Pierson, L. C. Kinney, B. P. Widmann, R. C. Beeler, Chairman, 712 Hume-Mansur Bldg., Indianapolis, Ind.

Committee on Hospital Relations: Ross Golden, New York City, Karl Kornblum, Philadelphia, Pa., J. J. Moore, U. S. Army, D. L. Palmer, Portland, Ore., I. H. Lockwood, Chairman, Kansas City, Mo.

Committee on Safety and Standards: E. C. Ernst, St. Louis, Mo., Otto Glasser, Cleveland, Ohio, R. R. Newell, San Francisco, Calif., B. P. Widmann, Philadelphia, Pa., Lauriston S. Taylor, Chairman, Washington, D. C.

Publication Committee: H. M. Weber, Rochester, Minn., E. P. Pendergrass, Philadelphia, Pa., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: H. J. Walton, Baltimore, Md., H. D. Kerr, Iowa City, Iowa, Robert Drane, Chairman, Savannah, Ga.

Committee on Scientific Exhibits: V. W. Archer, University, Va., P. A. Bishop, Philadelphia, Pa., S. W. Donaldson, Chairman, 326 N. Ingalls St., Ann Arbor, Mich.

Representatives on The American Board of Radiology: B. R. Kirklin, Rochester, Minn., U. V. Portmann, Cleveland, Ohio, LeRoy Sante, St. Louis, Mo.

Member, National Research Council: Ross Golden, New York City.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-second Annual Meeting: Cincinnati, Ohio, 1941.

THE AMERICAN RADIUM SOCIETY

President: Frederick W. O'Brien, Boston, Mass.; *President-Elect:* Hayes E. Martin, New York City; *1st Vice-President:* LeRoy Sante, St. Louis, Mo.; *2nd Vice-President:* Leland R. Cowan, Salt Lake City, Utah; *Secretary:* William E. Costolow, 1407 S. Hope St., Los Angeles, Calif.; *Treasurer:* Charles L. Martin, 3501 Gaston Ave., Dallas, Tex.

Executive Committee: E. H. Skinner, Chairman, Kansas City, Mo., W. P. Healy, New York City, L. A. Pomeroy, Cleveland Ohio.

Program Committee: H. E. Martin, Chairman, New York City, Harry Hauser, Cleveland, Ohio, George Sharp, Santa Barbara, Calif., A. W. Oughterson, New Haven, Conn.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., G. T. Pack, New York City, F. H. Rodenbaugh, San Francisco, Calif.

Research and Standardization Committee: Wilhelm Stenstrom, Chairman, Minneapolis, Minn., E. P. Pendergrass, Philadelphia, Pa., Otto Glasser, Cleveland, Ohio.

Education and Publicity Committee: H. N. Cole, Chairman, Cleveland, Ohio, Abraham Strauss, Cleveland, Ohio, J. T. Murphy, Toledo, Ohio.

Advisory Committee on Roentgen-Ray and Radium Protection: Edith H. Quimby, Chairman, New York City, E. C. Ernst, St. Louis, Mo., H. J. Ullmann, Santa Barbara, Calif.

Janeway Lecture Committee: Zoe A. Johnston, Chairman, Pittsburgh, Pa.

Committee on Arrangements: L. A. Pomeroy, Chairman, Cleveland, Ohio, J. R. Driver, Cleveland, Ohio, Harry Hauser, Cleveland, Ohio.

Representatives on American Board of Radiology: Douglas Quick, New York City, R. H. Stevens, Detroit, Mich., B. P. Widmann, Philadelphia, Pa.

Twenty-sixth Annual Meeting: Hotel Cleveland, Cleveland, Ohio, June 2–3, 1941.

EDITORIAL

DERMOID CYSTS OF THE OVARY

DERMOID cysts constitute nearly 20 per cent of all ovarian tumors. For a number of years their recognition in the roentgenogram was based entirely on the presence of teeth or other calcified shadows in the pelvic area. It has been pointed out that the apparent incidence of calcification of dermoid cysts varies between 18 and 49 per cent so there is a wide margin of error in their roentgen diagnosis.

Robins and White,[1] in a discussion of the roentgen diagnosis of dermoid cysts of the ovary, call attention to the desirability of additional reliable roentgen diagnostic criteria to make possible the detection of a larger number of these dermoids which do not contain teeth or calcareous material. In a group of cases, from a careful analysis of shadows in the pelvis, they were able to make a diagnosis of dermoid cysts of the ovary when the cyst contained no calcification. The sign which gave the clue to the diagnosis was the presence of a rounded or ovoid mass of decreased density, regular in its contour and usually presenting a banded mottled appearance. This mass, they found, is usually sharply delineated from the surrounding soft tissues by a thin ring of increased density, and one striking feature of their observation was that repeated examinations of the same region always presented a similar picture, so that the constancy of the finding represented confirmatory evidence. The mass was always found in the pelvis and usually in the vicinity of one of the ovaries. In some cases the cyst was quite large and occupied the greater portion of the pelvis. The diminished density of these tumors was explained by the nature of the contents of the dermoid cyst, a sebaceous material which is liquid at body temperature. Dermoid cysts all contain varying quantities of air mixed with the sebaceous material. This accounts for the banded mottled appearance characteristic of these ovarian tumors.

It was observed that all the cases showed a definite capsular ring of increased density. This was explained on the basis of the capsular structure of the dermoid cyst which is made up of thickened, stratified squamous epithelium and supporting fibrous tissue. These characteristics, even in the absence of calcification, have been, in the experience of Robins and White, sufficient to make a roentgen diagnosis of dermoid cyst and they also aided in the differential diagnosis of calcified shadows of doubtful origin in the pelvis.

More recently Good[2] made an analysis of the available cases at the Mayo Clinic in order to determine first, the incidence of Robins and White's sign and secondly, the frequency with which the diagnosis of dermoid cyst of the ovary may be made on the basis of what appears in the roentgenogram. From this study Good came to the conclusion that since recognized calcification exists in 40 per cent of all dermoid cysts and since Robins and White's sign is present in from 20 to 40 per cent of all such cysts, it is reasonable to suppose that a positive or presumptive diagnosis of dermoid cyst of the ovary can be made in at least 40 to 50 per cent of all such cases.

It is of interest, in the light of the recent work of Robins and White, to recall the observation which Phemister, Steen and Volderauer[3] made in the examination of der-

[1] Robins, S. A., and White, G. Roentgen diagnosis of dermoid cysts of the ovary in the absence of calcification. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 30–34.

[2] Good, C. A. The roentgenologic diagnosis of dermoid cyst of the ovary. *Proceed. Staff Meet., Mayo Clin.*, 1940, *15*, 265.

[3] Phemister, D. B., Steen, W. B., and Volderauer, J. C. A roentgenologic criterion of dermoid cyst. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 14–18.

moid cysts of the mediastinum, calling attention to a new sign for the roentgen diagnosis of this condition. In their discussion they noted a characteristic sign of such cysts, namely, the tendency to layering of floating fat and aqueous fluid as a new roentgenologic criterion for the diagnosis of dermoid cyst of the mediastinum. They stated, however, that obviously layering cannot be expected to show unless film, patient and roentgen tube are arranged so that the axis of the cone of radiation is directed approximately tangential to the surface of fat and aqueous fluid. This condition anatomically obtains routinely during chest roentgenography of the standing or sitting subject but not during roentgenography of the pelvis of the recumbent patient suspected of having a dermoid cyst of the ovary. But undoubtedly the clear cut shadows giving the characteristic signs of dermoid cysts of the ovary must be due in part to the layering of the contained fluids as was demonstrated in Phemister, Steen and Volderauer's observations on dermoid cysts of the mediastinum.

Since dermoid cysts of the ovary are not uncommon, their presence should be carefully searched for in all female patients presenting themselves for studies of the lumbosacral spine and pelvis and in the preliminary films taken previous to gastrointestinal studies. Familiarity with the roentgenologic sign as presented by Robins and White will increase the number of correct diagnoses.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Cincinnati, Ohio, 1941.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Next annual meeting: 1941, to be announced.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Cleveland, Ohio, June 2-6, 1941.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Cleveland, Ohio, Dec. 2–6, 1940.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. L. J. Taormina, 1093 Gates Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. H. A. Mahrer, 10515 Carnegie Ave. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. P. R. Weeks, 520 Republic Bldg., Denver, Colo. Meets third Friday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. J. N. Moore, 210 Professional Bldg., Ocala, Florida. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meetings held quarterly, on the fourth Sunday of the month.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. J. C. Bell, 402 Heyburn Bldg., Louisville. Meets annually in Louisville on third Sunday afternoon in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. J. E. Lofstrom, 1536 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. W. J. Marquis, 198 Clinton Ave., Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. E. J. Ryan, St. Luke's Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport Pa. Meets annually.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave. Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Hospital, Temple, Texas. Next annual meeting, January 18, 1941, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday of each month at the College Club, Seattle.

Cuba

Sociedad Cubana de Radiologica y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1, England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134 ,Louvain (Belgium). Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aertze.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly on first Monday at 8 o'clock.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St. Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen. Meets the second Wednesday of each month from October to July in Copenhagen, at 8'oclock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

REPORT OF THE RESEARCH AND STANDARDIZATION COMMITTEE OF THE AMERICAN RADIUM SOCIETY

The physical factors of importance for radium therapy were discussed in some detail in last year's report. It seems unnecessary to add further tables at this time but we wish to call attention to the "Inverse Square Law Table" for use in Radium Therapy by W. V. Mayneord. It has been proposed that the Society should distribute mimeographed copies of this pamphlet to the members. A number of papers referring to measurements and calculations of dosage distribution have been published during the last year. As a specific example may be mentioned: "Weak Radium Needle Technique in Carcinoma of the Cheek" by Charles L. Martin, Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 226–235. Numerous calculations and tables can also be found in the recently published three volumes, "Treatment of Cancer and Allied Diseases" by 147 Authorities, edited by George T. Pack and Edward M. Livingston.

The recent use of radioactive phosphorus for the treatment of leukemia shows that induced radioactive elements already have become of therapeutic importance. Apparatus for production of such substances are becoming more numerous and efficient. Radioactive isotopes of almost all the elements have been produced experimentally and a complete summary of the available data has been tabulated by J. J. Livingood and G. T. Seaborg in the article: "A Table of Induced Radioactivities," *Reviews of Modern Physics*, January, 1940, *12*, 30–46. Probably only a few of the radioactive isotopes will become therapeutically useful. With present methods and equipment two of them, namely sodium of atomic weight 24 and phosphorus of atomic weight 32 have been produced in sufficient quantities for therapy. The physicists working with the cyclotrons at the University of California have calculated the possible output when 8 million volt deuterons and 50 to 100 microamperes current are used. They conclude that 5 curies of radioactive sodium can then be obtained at saturation and 30 millicuries of radioactive phosphorus can be obtained if an exposure of 1 milliampere-hour is given. The quantities obtainable of other radioactive isotopes are very much smaller. The important data of these isotopes are given in the following table:

Element	Type of Radiation	Half Life	Energy of Radiation in Million Electron Volts	
			Particles	γ-Rays
$_{11}Na^{24}$	β, γ	14.8 hours	1.4	1, 2, 3
$_{15}P^{32}$	β	14.3 days	1.69	No γ-rays

E. P. Pendergrass
Otto Glasser
K. Wilhelm Stenstrom, *Chairman*

BULLETIN OF THE INTER-SOCIETY COMMITTEE FOR RADIOLOGY

COLLECTION OF FEES

For a number of years there has been considerable discussion concerning the best methods for collection of fees for radiological services performed in the hospital. Frequent reference to this subject has been included in the literature published by the American College of Radiology and the Inter-Society Committee for Radiology.

It has been argued that collection of radiological fees on a billhead bearing the name of the radiologist created a favorable impression upon patients and referring physicians alike. Too often, it has been said, a patient is discharged from a hospital, paying a bill at the cashier's office which included a charge for X-ray services, without ever realizing that he has received a consultative service from a physician-specialist in radiology. The patient is apt to tell his friends that "The hospital made some X-ray pictures and Dr. Jones [his attending physician], after studying them, decided I

was going to be all right." Indeed, there are instances when a patient receives roentgen therapy and is actually cured of a cancer, without knowing the identity of the radiologist who effected that cure.

Cognizant of these occasional situations, the Manual of Desirable Standards for Hospital Radiological Departments of the American College of Radiology expressly recommends that radiologists practicing in hospitals render bills and collect, themselves, for their professional services to patients. That these recommendations have not been entirely ignored is indicated by the fact that today more than 20 per cent of all radiologists collect in the radiological department for services to hospital patients or render separate bills on their own billhead which are collected by the hospital cashier. In a recent study by the Inter-Society Committee for Radiology, it was revealed that this is the practice in 197 hospitals.

Recently, the Board of Trustees of the American College of Surgeons, considering the tendency for hospitals to assume the rôle of a middleman in the relationship between doctors and their patients, adopted a set of principles pertaining to the financial relations in the professional care of patients in the hospital. The following provisions in that set of principles, now incorporated in the "Manual of Hospital Standardization" of the American College of Surgeons, are of particular interest to radiologists:

1. Each doctor who participates in the care of a patient is entitled to compensation from the patient commensurate with the services rendered.

2. Whenever practicable and possible the attending doctor should acquaint his patient with his financial responsibility to those concerned with his care.

3. Each doctor concerned in the care of a patient should give or send directly to the patient a detailed statement showing charges for professional services rendered.

4. Combined statements should be avoided, as they may constitute a subterfuge for fee-splitting.

5. Each doctor who participates in the care of the patient should send a personal receipt directly to the patient for all moneys received from the patient or other legitimate or authorized source.

6. Insofar as possible, a third person should not enter into the financial relations between doctor and patient, and to this end hospitals should be discouraged from determining or collecting fees for doctors.

7. An exception to the foregoing principles must, of necessity be made when there is a formally organized clinic or legal partnership which in effect may be regarded as an individual and which acts in that capacity. This principle should apply also when the clinic and hospital are combined and under the same ownership.

* * * *

The following bulletins were sent by the American College of Radiology to its list of state representatives and the secretaries of regional radiological societies last month. They are published herewith for the information of all radiologists:

SELECTIVE SERVICE EXAMINATIONS

This bulletin is to advise you concerning procedures adopted for the examination for physical qualifications of registrants under the Selective Service Act. Some details in this procedure have not yet been completed and as a consequence the information contained herein may be supplemented or revised in future bulletins. Dr. Vincent W. Archer, Chairman of the Board of Chancellors, has authorized this office to disseminate all pertinent information of special interest to radiologists in connection with Selective Service as subsequent regulations are adopted.

The basis responsibility of determination as to physical qualifications of registrants will rest on local draft boards in some 6,500 communities. Local boards under Selective Service Regulations have original jurisdiction with respect to physical qualifications of registrants, subject to appeal. Each local board will have one or more examining physicians who will examine all registrants sent to them by the local board. Standards of physical examinations will be furnished them. It is estimated that there will be about 90 men per local board requiring physical examination. Examining physicians will be appointed

by the President upon recommendation of the Governors of the respective States. They will serve without pay.

Provision has been made to furnish the supplies required in physical examinations and to pay on a cost basis for those procedures necessary for the determination of a draftee's physical fitness, such as laboratory or x-ray examinations. A subcommittee of the Committee on Medical Preparedness has been appointed to establish a schedule of charges on the basis of which pathologists, radiologists, and other special examiners will be reimbursed for the costs incurred in making examinations referred to them. This schedule has not yet been completed.

As provided in the Selective Service Act (Section VII-146), Medical Advisory Boards "shall be appointed by the governor of each state to assist local boards in determining the physical qualifications of registrants. The Board shall, if practicable, consist of internists; eye, ear, nose, and throat specialists; orthopedists; surgeons; psychiatrists; clinical pathologists, radiographers; and dentists. In the event that a Medical Advisory Board cannot be made available to a local board, the governor shall appoint individual specialists who shall act as a Medical Advisory Board."

The chairman of each Medical Advisory Board shall authorize such special examinations and laboratory tests as he may deem necessary and shall cause to be forwarded to the State Procurement officer for payment the bill for such examinations (Section VII-529).

It is unfortunate that the term "radiographers" was used in the Act. However, it is obvious that the officials of Selective Service contemplated the employment of licensed radiologists in private offices and hospitals to perform examinations when such are indicated.

Physicians appointed to the Medical Advisory Boards are being asked to sign a waiver of "any right to pay or compensation in any form whatsoever for services." (Form DSS-257.) In the case of radiologists appointed to the Medical Advisory Boards, this conflicts with the agreement to defray the costs of x-ray examinations. We suggest, therefore, that radiologists appointed to the Medical Advisory Board delete the sentence quoted above and substitute therefor something similar to the following:

> I hereby expressly waive any right to pay or compensation in any form whatsoever for services rendered as a consulting radiologist in matters of special opinion or advice which may arise in the work of this Board; except that, for any roentgen examinations requested of me by this Board of local draft boards. I shall expect reimbursement on a reasonable basis for the actual expenses incurred in performing such roentgen examinations; and the right to compensation for those costs I hereby expressly retain.

Roentgen examinations of the chest will be ordered by local examining physicians only as required in order to determine definitely whether a draftee is physically fit and will not be required for all draftees.

After having been selected for service by the local draft boards, and following the adjudication of any appeal, a registrant is referred to an "Induction Board" in his Corps Area. He is now in the Army. The Induction Board will order a complete physical examination which will include routine chest films to be made with special x-ray units, approximately 100 of which have been ordered by the Army. Civilian physicians serving on these Induction Boards will be paid on a per diem basis.

It is our request that state representatives of the Inter-Society Committee and secretaries of regional societies receiving this bulletin assume the responsibility for notifying all radiologists in their state of the information contained in this bulletin. The names of radiologists appointed to the Medical Advisory Boards, of which there will be several in each state, can be obtained from the Adjutant General's office in your state. This list may also be obtained from the Medical Preparedness chairman of your state society. Will you please make it your duty to see that this information is placed in the hands of all radiologists so appointed?

We respectfully suggest also that the recipients of this bulletin in the various states assume the responsibility of providing a list of qualified radiologists available for examination of draftees to the Adjutant General in your state. His office, in turn, can relay this information to the respective Selective Service Boards and Medical Advisory Boards.

As additional information is received at this office, it will be forwarded to you in subsequent bulletins. Meanwhile, we shall depend upon you to disseminate this information in your locality. A special meeting of your state or regional radiological society might be advisable. If further questions occur to you, please do not hesitate to call upon this office for any information we may be able to give you.

COST SCHEDULES FOR SELECTIVE SERVICE EXAMINATIONS

In our Bulletin of October 29, we reported that a subcommittee of the A. M. A. Committee on Medical Preparedness was preparing a schedule of costs, upon the basis of which radiologists would be reimbursed for actual expenses incurred in performing examinations on draftees. It now appears that no national schedule will be prepared. Instead, the local Committee on Medical Preparedness of the various state medical societies will draw up schedules of cost-fees for the respective States. The schedules for New York State has already been adopted.

We suggest that you communicate with the chairman of your State Committee on Medical Preparedness relative to the schedule for your State. Perhaps it will be desirable to appoint a special committee of radiologists to prepare and submit the schedule. It should include a reasonable and representative list of cost-fees for all procedures likely to be performed on draftees and be suitable for all sections of the State.

Please forward to this office the schedule adopted for your State as soon as it is available.

In some localities radiologists have agreed among themselves to assume the costs for these examinations as a patriotic contribution to the cause of military preparedness. The probabilities are that, in most localities, no great number of roentgen examinations will be requested, either on the order of examining physicians or the local Medical Advisory Boards. Dr. A. C. Christie, Chairman of the Advisory Committee for Radiology of the National Research Council believes that the burden on any individual radiologist will, in most instances, be small.

* * * *

The following information will be of interest to radiologists within the draft age in your locality. It is understood that all physicians drafted will be given posts appropriate to their specialty, if any, when inducted into the medical corps. The Surgeon-General of the Army will obtain information regarding specialists from the A. M. A. Committee on Medical Preparedness. The American College of Radiology, the American Board of Radiology, and the Advisory Committee for Radiology of the National Research Council will assist the A. M. A. Committee in determining qualifications of all those listing themselves as radiologists on the A. M. A. questionnaire. When inducted into service a radiologist should immediately notify the local Corps Area Commander of his preference for roentgenology.

MAC F. CAHAL
Executive Secretary

ABNORMALLY WIDE RESPIRATORY MOVEMENT

To The Editor:

In the article "Abnormally Wide Respiratory Movement of Lower Lung Structures: Roentgen Evidence of Obstructive Emphysema," which appeared in the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY, 1940, *44*, 325, I make the statement that the physical phenomena of obstructive emphysema were first demonstrated in 1908 in MacCallum's laboratory by Thornton and Pratt on an experimental lung preparation, and that Iglauer in 1911 described a case of obstructive emphysema in a child due to a foreign body.

Dr. George W. Holmes has called my attention to the fact that the phenomena of obstructive emphysema were described by Dr. Francis H. Williams. In the Third Edition of Williams' book "The Roentgen Rays in Medicine and Surgery," The Macmillan Company, New York, 1903, on page 347 he describes the examination of a patient as follows: "I examined the patient with the fluorescent screen, and found that there was a dark area in the neighborhood of the aorta, . . . , but there was no pulsation of these abnormal outlines; that there was obstruction to expiration; that the lungs were dilated to their fullest extent; that the diaphragm was low down in the chest, nearly as far as the costal border, and moved very little in expiration." He then goes on to state that the differential diagnosis lay between a mediastinal new growth and an aneurysm, and that autopsy showed the shadow in question to be due to "a bunch of enlarged glands about the size of a small orange." In further discussion of this case he says, "In this patient the absence of pulsation in the outlines seen on the screen, and the obstruction to expiration on both

sides, were opposed to the diagnosis of a small aneurism. In other patients I have observed this incomplete expiration and depressed diaphragm in one or in both lungs where there was obstruction of the air passage of one or both of these organs, due to some other cause than an aneurism. I recall one case in which there was obstruction of the left bronchus due to a well-marked aneurism, and in which the diaphragm also was depressed and had little movement."

Obviously Williams observed cases of obstructive emphysema due to partial bronchial obstruction. I regret that I was not familiar with his report at the time the article was presented and am glad to take this opportunity to give him credit for his early and remarkably accurate roentgenologic observations.

Ross Golden

INSTITUTE OF RADIOLOGY

As a part of the post-graduate medical education program in New York State, an Institute of Radiology will be held at the Syracuse University College of Medicine, Syracuse, New York, on Saturday, January 18, 1941. The meeting will be called to order at 1:30 P.M. The following papers will be given: "Physics of Radiation for the Radiologist" by Edith H. Quimby, Sc.D., Memorial Hospital, New York; "Roentgenological Aspects of Brain Tumors, Diagnosis and Treatment" by Merrill C. Sosman, M.D., Peter Bent Brigham Hospital, Boston; "Indications and Results of Roentgen Therapy" by U. V. Portmann, M.D., Cleveland Clinic, Cleveland, Ohio; "Radiosensitivity of Tumors" by Fred W. Stewart, M.D., Memorial Hospital, New York; "The Cyclotron," by Stafford L. Warren, M.D., Strong Memorial Hospital, Rochester, N. Y. A dinner meeting will be held at 7:00 P.M. at the Hotel Syracuse. The speaker will be R. R. Spencer, M.D., Assistant Chief, National Cancer Institute, United States Public Health Service. While the Institute is planned especially for radiologists, all physicians in the State are cordially invited to attend. The price of the dinner is $2.00. No other fees will be charged. The sponsoring agencies wish to know how many plan to attend the afternoon session and the dinner. Reservations should be addressed to Dr. O. W. H. Mitchell, 428 Greenwood Place, Syracuse, New York.

OFFICERS ELECTED

The officers elected at the recent meeting of the American Roentgen Ray Society for 1940–1941 are as follows: *President:* Dr. Merrill C. Sosman, Boston; *President-Elect:* Dr. William McD. Doughty, Cincinnati, Ohio; *1st Vice-President:* Dr. Gordon E. Richards, Toronto, Canada; *2nd Vice-President:* Dr. J. C. Dickinson, Tampa, Florida; *Secretary:* Dr. Carleton B. Peirce (re-elected), Montreal, Canada; *Treasurer:* Dr. J. Bennett Edwards (re-elected), Leonia, N. J.; *Historian:* Dr. Percy Brown (re-elected), Boston, Mass.; *Member of the Executive Council:* Dr. B. P. Widmann, Philadelphia, Pa. Cincinnati was chosen as the place of the Forty-second Annual Meeting in 1941.

AMERICAN RADIUM SOCIETY

The Twenty-sixth Annual Meeting of the American Radium Society will be held on June 2 and 3, 1941, in Cleveland, Ohio, at the Hotel Cleveland.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

THE MEDICAL CAREER, AND OTHER PAPERS. By Harvey Cushing. Cloth. Price, $2.50. Pp. 302. Boston: Little, Brown and Company, 1940.

The Medical Career forms a companion volume to Consecratio Medici which was published by Cushing in 1928. The material consists of seven essays which deal with subjects of a general medical nature, and nine short biographical sketches of well known physicians, with the exception of one devoted to the famous historian, James Ford Rhodes. "The Medical Career," from which the book takes its name, is an essay which was presented at Dartmouth College on November 20, 1928. It well deserves the thoughtful perusal of all those associated with the medical profession, in addition to those contemplating study for this profession. It is Harvey Cushing in his full stride, discoursing in his engaging manner upon topics about which he is amply qualified to speak with the authority of many years of experience and thoughtful meditation. A typical example of his ability to state things tersely is found in his definition of the art of medicine which, according to him, "requires . . . an understanding of human nature, abounding unselfishness, unflagging sympathy, and observance of the Golden Rule," and "has reference, among other things to the practicing doctor's ability to inspire confidence in his patients and their relatives." Surely this is one of the most acceptable definitions of this phase of medicine which has ever been expressed, and to many it doubtless will reveal an unexpected angle of Harvey Cushing to those who knew him only as a master of the science of medicine.

Throughout his essays are expressed certain piquant views regarding medical education and physicians, that are deserving of careful consideration. He is not at all sure that the premedical student should devote a major portion of his time in college to the fundamentals of biology, physics and chemistry, for there are probably other subjects which are equally essential and useful to the future life of a doctor. Although there is a growing tendency of medical educators to agree with this view, Cushing is not inclined to argue this point to the bitter end.

He expounds briefly but eloquently concerning the "abounding credulity of human nature" which causes the public to turn to the quacks, the charlatan, and patent medicines, and expresses his unfavorable opinion in biting terms of groups which would prevent the advance of medicine by legislation calculated to prevent animal experimentation and vaccination.

Cushing always had interesting and provocative views of his own concerning various medical questions, which he was equipped to defend vigorously. For example, he holds that although doctors rarely urge their sons to study medicine, they often do so, and he is inclined to attribute this to some insignificant incident or a fortuitous encounter. It is true that circumstances such as these may be the precipitating factors upon which a young man's future course hinges but the parental daily example and influence cannot be disregarded as being an important determining cause in many instances.

Throughout the essay on The Medical Career there is justifiable emphasis on the wisdom of bringing medical students into contact with patients early in their medical training rather than guarding them carefully from them during the first two years in medical school. He advocates, in a modified way, the logic of the old apprentice system. There is a growing tendency for medical educators to accept this rational view to a certain extent as indicated by the presentation of medical clinics to first year students. But this, too, requires some regulation as it should never encroach seriously upon the time devoted to the fundamental sciences.

The author's statements regarding certain subjects are so gratifying to the profession that one example in the essay must be quoted in toto as follows: " . . . if the politicians could only do as much toward the elimination of war, and the commercial distributors of food as much toward the elimination of famine, as the doctors have toward the elimination of pestilence, this world would be a more secure and happier place in which to await the arrival of the last of the Four Horsemen." Such a thought is so appropriate at the present moment.

Cushing bows to the progress of science and

predicts that the next generation of physicians will look upon the present day knowledge of medicine with pity, but he warns them to be charitable for their own turn, too, will come. He does not believe that formal lectures and perfunctory class room work are important in learning, but emphasizes that it is chance encounters which chiefly influence us. This may be interpreted as meaning that true knowledge comes mainly from one's own efforts, although the stimulus to learn frequently arises from others. Of course this may also result from formal teaching but in his own experience it came apparently from other sources.

"From Tallow Dip to Television" was the annual discourse given before the Massachusetts Medical Society at its 150th reunion in 1931. It recounts the history of the Society and pays tribute to its founders. "Medicine at the Cross Roads" is an astute presentation of some of the problems which now confront the medical profession and one which contains much food for thought. As an example, a portion of one sentence is given as follows: " . . . the Medical Profession finds itself overmanned, overspecialized . . . , like other necessities of life poorly distributed, an expensive luxury to those of modest means and the subject of investigation by a commission which threatens us with socialization unless we promptly do something to alter our spots, to cast off our long-conditioned reflexes, and put ourselves on a modern chain store business basis."

An attempt to analyze the views advanced in these essays is not within the scope of this review or the ability of the reviewer for they contain many diverse views concerning the practice of medicine, research, medical history and education, and many ideas concerned with life in general. These are all conclusions from the mind of a man who was a master surgeon, a stimulating teacher, an explorer of new fields in medicine, and a student of medical history. Combined with these interests, he had the ability to write with a facile pen, which was sometimes shaped to an exceedingly fine point.

Cyrus C. Sturgis

Handbook of the Hospital Corps, United States Navy, 1939. Published by the Bureau of Medicine and Surgery, under the authority of the Secretary of the Navy. Cloth. Price, $1.75. Pp. 1015, with 201 illustrations. Washington, D. C.: U. S. Government Printing Office, 1939.

This Handbook is a revised edition of the former Handbook of the Hospital Corps published in 1930, It is compiled from articles prepared by members of the Medical, Dental, Hospital, and Nurse Corps, United States Navy, and was reviewed and revised by Commander W. J. C. Agnew, Medical Corps, and Chief Pharmacist N. L. Saunders, U. S. Navy. It is published for the instruction and guidance of the members of the Medical Department of the Navy and for use at the Hospital Corps Schools.

The Handbook is a large volume of 1015 pages. In the Foreword it is stated that the principal subjects have been arranged in order in which they occur in examinations for advancement in rating, and, as these subjects are necessarily presented in epitomized form, it is suggested that the information contained in the various chapters must be supplemented by reference to the standard textbooks and professional journals usually available in the medical libraries of hospitals, ships and stations.

The subjects covered are too numerous to mention in a brief review of the book. They cover all phases of knowledge necessary to carry out the duties of the Hospital Corps. The chapter on anatomy and physiology covers 84 pages and is well illustrated with numerous drawings and sketches of the bones of the skeleton, the muscles, histological sections, circulation of the blood, and the processes of digestion. The chapter on the roentgen ray gives first a brief historical account of the discovery of the x-rays, and is followed by sections on their nature and production with description of the various roentgen tubes, transformers and other roentgen-ray equipment. The methods of roentgen examination by the use of the fluorescent screen and the film are given in detail. The process of developing films is described. Rules and regulations for operations of roentgen equipment and for proper protection from the effects of too much irradiation complete the chapter. No attempt is made to describe the technique for roentgenographic examination of the various parts of the body.

In spite of the mention in the Foreword of the necessity for consultation of standard textbooks, the reader is impressed by the magnitude of the work and by the thorough and painstaking manner in which the material has been collected and arranged. All the chapters are uniformly well written, in clear and concise style. The physician in civilian life will find in it much

that is of interest and benefit. Chapters such as those on anatomy and physiology and the roentgen ray could well be used as a basic course for the teaching and training of roentgenological technicians.

R. S. Bromer

Fourth Saranac Laboratory Symposium on Silicosis. An official transcript of the Fourth Saranac Laboratory Silicosis Symposium held in connection with the Trudeau School of Tuberculosis at Saranac Lake, N. Y., June 19 to 23, 1939. Edited by B. E. Kuechle, Vice President and Claims Manager, Employers Mutual Liability Insurance Co. Wausau, Wisconsin. Paper. Pp. 379. 1939.

This small monograph contains a wealth of material for those who are interested in silicosis. There is a brief summary of all the phases of what is known about the etiology, pathology and diagnosis of silicosis. In addition, there are studies of inert dust and a report of clinical investigations in a number of the various industries. For those who may be interested in the organizational side of pneumoconiosis and silicosis prevention, there is adequate discussion of this phase of the problem, together with the consideration of the employer's viewpoint and the viewpoint of the insurance carrier and the function of the state in the control of silicosis. In the final chapters of the book there is an adequate discussion of the silicosis legislation and the Wisconsin preemployment examination program. This small monograph seems to the reviewer the best study that has been published in the United States on the silicosis problem and it is hoped that it will be read widely and stimulate others to make similar investigations.

Eugene P. Pendergrass

Anatomy of the Human Lymphatic System. By H. Rouvière, Professor of Anatomy at the Medical Faculty of Paris, France. A Compendium. Translated from the original *Anatomie des lymphatiques de l'homme* and rearranged for the use of students and practitioners. By M. J. Tobias, formerly of the Department of Anatomy, New York University, School of Medicine, Assistant Radiologist, Montefiore Hospital, New York. Cloth. Price, $4.50. Pp. 318, with 129 illustrations. Ann Arbor, Mich.: Edwards Brothers, Inc., 1938.

This classical work has now been carefully translated into English by Tobias, who has improved the original book by additional notes and a glossary. The lymphatic supply of every viscus and every region of the body is given in orderly detail with clear semi-diagrammatic illustrations. The French volume has long been a necessary unit in every anatomist's library, but now that it is available in English, it should be in the hands of every radiologist, pathologist, and surgeon, particularly those who are interested in the diagnosis and treatment of cancer and allied diseases. The sections dealing with the lymphatic supply of the breast, oral cavity and gastrointestinal tract are invaluable. It is this reviewer's opinion that every cancer therapist would improve the results of his treatment by the application of knowledge derived from a study of this book.

George T. Pack

Peripheral Vascular Diseases: Diagnosis and Treatment. By William S. Collens, B.S. M.D., Metabolist, Chief of the Clinic for Peripheral Vascular Disease, Chief of the Diabetic Clinic, Israel Zion Hospital, Brooklyn, etc., and Nathan D. Wilensky, M.D., Assistant in Clinic for Peripheral Vascular Disease, Assistant in Diabetic Clinic, Israel Zion Hospital, etc. Cloth. Price, $4.50. Pp. 243, with 77 illustrations. Springfield, Illinois: Charles C Thomas, 1939.

This work is an excellent and practical monograph, well and clearly written. The various aspects of peripheral vascular diseases are considered systematically, following a résumé of the anatomical and physiological background. Peripheral vascular diseases have been so clarified by recent anatomical and physiological research that the general practitioner, the internist, and the surgeon should have such a vade mecum. Therapy has been rightly stressed. Of the works on this subject, this one ranks high and, because of its practical presentation especially, is it recommended. The typography and make-up of the book add in no small way to its readability.

Harold Feil

Symposium on the Synapse. By Herbert S. Gasser, Joseph Erlanger, Detlev W. Bronk, Rafael Lorente de Nó, and Alexander Forbes. Cloth. Pp. 361–474. Springfield, Illinois: Charles C Thomas, 1939.

The book, dedicated to Ch. S. Sherrington, who introduced the concept of the synapse into neurophysiology, represents an excellent review

of the different electrophysiological aspects of synaptic transmission of nerve impulses. During recent years much work has been done on the possible rôle of chemical substances involved in transmission across synapses. Whatever the results of these investigations may be, the important achievements of electrophysiology, the fundamental laws established by the highly developed electrical methods must be taken into account by each comprehensive theory of synaptic transmission. It must therefore be greatly welcomed that in this collection the best authorities in electrophysiology represent their present conceptions of the problem. The possibility of chemical reactions connected with the synaptic mechanism is only occasionally mentioned and to a certain extent discussed in the contributions of Bronk and Forbes.

Gasser considers the "axons as samples of nervous tissue." Their properties may not differ, qualitatively at least, from other parts of the neuron. Events taking place in the axons, where they can be observed much easier, may resemble those of the synapse. He describes the subnormal excitability of different axons following single spikes or trains of spikes and shows that this phase of subnormal excitability is characteristic of all parts of the neuron.

Erlanger discusses the question whether conduction of excitation has peculiar features at synapses not to be found in nerve trunks. His arguments are based on observations made on latency, one-way transmission repetition, temporal summation or facilitation and transmission of the action potential across a nonconducting gap. It results from these observations "that there is a close correlation temporarily between (I) the subthreshold effect of a shock applied to a fiber (II) the subthreshold effect of an action potential beyond a block at a node and (III) the subthreshold effect of an action potential blocked at the neuromuscular junction by curari." There is no reason to believe in a fundamental difference between nerve fiber and synapse conduction.

Bronk analyzes the synaptic mechanisms in sympathetic ganglia. Different factors have to be correlated in order to understand the nature of the discharge of a ganglion cell. A cellular discharge is initiated not by a single presynaptic impulse but by a number of them; its frequency depends not only upon the frequency of impulse in any one presynaptic fiber but by the level of "excitatory state" developed by the unrelated rhythms in a number of fibers. The degree of activity is determined by the combined effects of various agents in the environment of the cell. Acetylcholine and potassium ions must be considered as such agents. Oxygen is another important factor. The conditions at the synapse are modified from moment to moment in accordance with their changing environment and their previous activity.

Lorente de Nó's contribution is an analysis of transmission of impulses through cranial motor nuclei. The internuncial neurons lying between sensory nerves and motor nuclei are also included. A rich anatomical material is brought greatly facilitating the understanding of the physiological study. Important data are brought on the duration of synaptic delay on the refractory period, on facilitation and on spatial and temporal summation. A new model of synaptic transmission is suggested, based on observations which represent a modification and interesting enlargement of Wedensky's experiments.

Forbes reviews the different developments and aspects of synaptic transmissions. He emphasizes the importance of the many factors involved and warns, in view of the complexity of the nervous system, to beware of adopting too readily alluring schemata. "Electrical" and "chemical" mechanisms have to be taken into account for a final satisfactory theory. There are many questions still open.

David Nachmansohn

Traumi Cranici: Chirurgia—neurologia—radiologia. By Mario Lapidari, Ludovico Mucchi, and Virginio Porta. Con un capitolo sulla lesioni auricolari da trauma cranico di F. Carnevale Ricci. Prefazione de Mario Donati. Paper. Price, 50 lire. Pp. 430, with 101 illustrations. Belluno: Edizioni Casa Editrice Libraria Antonio Salvador, 1938.

This monograph describes the observations of a neurosurgeon, a neurologist and a roentgenologist in the diagnosis and treatment of over 100 cases of skull fracture.

Of particular interest from a roentgenological standpoint are the chapters dealing with the diagnosis of fractures and those dealing with the use of encephalography and arteriography for the differentiation of subdural hemorrhages from cerebral edema.

As a whole, the authors seem to be much more aggressive than the average. In many of their cases they performed encephalography a few hours after the injury. They claim that this

procedure not only is not followed by ill results but, by substituting a compressible gas for the incompressible spinal fluid, gives a better and longer decompressive effect while it allows roentgenographic studies to be done. Aside from the clinical aspect of this method, the study of the published roentgenograms and of the diagnostic criteria followed by the authors leaves one somewhat in doubt as to the diagnostic usefulness of the procedure. On the contrary the demonstration of subdural hemorrhage obtained by means of arteriography is one of striking certainty and it should be very useful when a cerebral hemorrhage seems to be in progress and an accurate diagnosis and localization is desirable.

Cesare Gianturco

Beiträge zum Verständnis der Leistungsfähigkeit des medizinischen Durchleuchtungsverfahrens. Von Helge Christensen. Paper. Pp. 218, with 57 illustrations. Kopenhagen: Ejnar Munksgaard, 1939.

During recent years there has been considerable discussion regarding the accuracy of the fluoroscopic screen examination in the determination of early tuberculosis of the lungs. Opinions are still at variance; while roentgenologists are as a rule skeptical, specialists in tuberculosis seem more enthusiastic about the screen method. In order to obtain an objective answer to the question, the author has carried out a series of accurate studies of the efficacy of the fluoroscopic screen by means of the photometric method. The sensitivity of the human eye, the degree of fluorescence of a screen, the influence of scatter and contrast are discussed at length. An analysis of the results of the investigations seems to indicate that given favorable location—no interference by superimposed shadows—a lesion of pea size can be detected on the screen. Below that size it is highly questionable or even impossible. While the screen examination is undoubtedly of value, much improvement is required before it can be considered adequate as a single method of examination in the detection of small tuberculous lesions in the lungs.

E. A. Pohle

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

Paleari, A.: Large intracerebral calcification probably of traumatic origin 921
Simonetti, A.: Calcifications of crystalline lens and vitreous 921
McClelland, J. E.: Syndrome of hydromicrocephaly 921
Erba, L.: A case of rhinolith 922

Neck and Chest

King, J. B.: Calcification of the costal cartilages 922
Hasley, C. K.: Radiology's responsibility in diagnosis and treatment of thymic hyperplasia 922
Mitchell, A. G., and Warkany, J.: Problem of thymus in children 923
Hosen, H.: Thyroid deficiency in twins 924
Lincoln, E. M., Smith, C. H., and Kirmse, T. W.: Subacute pneumonia in children ... 924
Cohen, A. G., and Wessler, H.: Clinical recognition of tuberculosis of major bronchi .. 924
Hunt, L. W.: Roentgenograms of the chest and the intracutaneous tuberculin test for adults 925
Cole, G. C.: Structural changes in lungs of drug addicts 925
Cohen, A. C.: Incidence of pulmonary and extrapulmonary tuberculosis in anthracite coal miners 926
Zubiani, G.: Changes in roentgen image of lung outline from pharmacodynamic action 926
Giordano, G.: Echinococcus cyst with detachment 926
Lura, A.: Changes in size and shape of heart shadow in some cases of chronic pulmoary tuberculosis 927
Berk, L. H.: Roentgen diagnosis of mural thrombi 927
Meyer, A.: Kymography as aid in differential diagnosis of mediastinal tumors 928

Abdomen

Baccaglini, M.: Roentgen contribution to study of ulcer of greater curvature of the stomach 928
Anzilotti, A.: Malignant course of hypertrophic gastritis 929
Fugazzola, F.: Function of duodenum in some diseases of the stomach 929
Colosimo, C.: Foreign bodies in the duodenum 929
Nuzzo, L.: Case of stenotic tuberculosis of the jejunum 930
Anzilotti, A.: Hyperplastic ulcerous regional ileitis 930
Marzocchi, G.: Passage of opaque paste into colon under normal conditions 931
Guidotti, C.: Accessory pancreas of wall of duodenum and its roentgen image 931

Gynecology and Obstetrics

Massari, G. M.: Ileovesical fistula 931

Genitourinary System

Muscettola, G.: Unusual case of transparent intrauretero-pelvic calculus in ureteropyelography 932
Anzilotti, A.: Late results of severe injury of the kidney 932
Buisson, M., and Lovotti, S.: Can intravenous urography be considered a test of renal function? 932
Cope, O., and Schatzki, R.: Tumors of adrenal glands 933

Skeletal System

Nicotra, A.: Study of familial character of Mediterranean fever or Cooley's disease 934
Guarini, C.: Xanthomatosis 934
Cignolini, P.: Roentgen therapy of Hand-Schüller-Christian's disease 934
Perlman, H. H.: Chronic Gaucher's disease ... 935
Moller, P. F.: Chronic fluorine poisoning, seen from roentgenological standpoint 935
Agati, D.: Idiopathic cysts of clavicle in young subjects 936
Hall, R. D. McK.: Clay-shoveler's fracture .. 936
Cleaves, E. N.: Unusual shoulder lesion 937
Dickson, F. D., Diveley, R. L., and Helwig, F. C.: Thyroid tumor of humerus without demonstrable goiter 937
Lauro, A.: Roentgen study of human humerus 937
Runco, A.: Roentgen iconography of anomalies of development of the limbs—pictures produced by excess 938
Runco, A.: Roentgen iconography of anomalies of development of the limbs—pictures caused by defect 938
Gillespie, J. B., and Siegling, J. A.: Dysostosis multiplex 938

Horwitz, T., and Cantarow, A.: Polyostotic fibrous dysplasia 938
Nathan, L., and Kuhns, J. G.: Epiphysitis of the spine 939
Dietrich, H. F., Karshner, R. G., and Stewart, S. F.: Tetanus and lesions of the spine in childhood 939
Batt, R. C., and Hampton, A. O.: Spontaneous subcapital hip fractures occurring in tabes dorsalis 940
King, D., Leef, E., and Terwilliger, C. K.: Importance of accurate roentgenography and interpretation in femoral-neck fractures treated by internal fixation 940
Codecà, G.: Roentgen images in course of tuberculosis of the pubis 941
Ulrich, H.: Multiple myeloma 941
Tarr, L., and Ferris, H. W.: Multiple myeloma associated with nodular deposits of amyloid in muscles and joints and with Bence Jones proteinuria 942
Thomason, H. A., and Mayoral, A.: Syphilitic osteomyelitis 943

MISCELLANEOUS

Günsel, E.: Pendulum irradiation with moving and fixed fields of incidence 943
Cardillo, F.: Theoretical consideration and experience in roentgenography at very short distances 944
Gilardoni, A.: Rapid control of roentgen times of exposure with a fluorescent screen with long residual luminosity 944

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Paleari, Antonio. Vasta calcificazione endocerebrale di probabile origine traumatica. (Large intracerebral calcification probably of traumatic origin.) *Radiol. med.*, Sept., 1939, *26*, 857–862.

The patient, a man of thirty-one, had had no personal history of any importance until 1936 when he suffered a severe injury of the skull in an automobile accident. He lost consciousness for four days and showed signs of cerebral concussion. When he regained consciousness he had a left hemiparesis and headache. He was sent to various hospitals in Africa and Italy and was finally sent to a Neurological Institute for examination for pension.

Examination showed left hemiparesis, increased intracranial pressure and a large calcified area oval in form and with distinct outlines, above the third ventricle and extending to the right. Examination of the spinal fluid was practically negative. Functional tests showed slightly defective function of the diencephalo-hypophyseal region.

The author reviews all the pathological processes which might cause calcification in the brain. By appropriate methods of examination he excludes tuberculosis, syphilis, encephalopathies, old abscess and parasites, such as echinococcus and cysticercus. He considers the possibility of meningioma, craniopharyngioma and glioma and also the possibility of a silent brain tumor which had been activated by the trauma. He rejected these possibilities, however, and concluded that the most probable diagnosis was that of a calcified traumatic hematoma.—*Audrey G. Morgan.*

Simonetti, C. Calcificazione del cristallino e del vitreo. (Calcifications of the crystalline lens and vitreous.) *Radiol. med.*, Oct., 1939, *26*, 963–964.

A patient forty years of age came for examination in August, 1935, for an injury of the skull. In addition to the signs of fracture there was a slightly opaque shadow in the left orbit with indistinct outlines; it was roughly circular and about 8 mm. in diameter. This image was enclosed in a larger circle, only a part of which corresponding to the inner margin of the orbit was visible.

The patient was seen again in February, 1936. The image previously seen was denser than it had been and its outlines more distinct and it was still enclosed in a circle of which only the inner part was visible, but this was much more distinct than before. In the left latero-lateral projection there was a lenticular image convex anteriorly and flattened posteriorly, about 8 mm. in height and 3 mm. thick. The circle described above was not visible in the lateral projection because it was not opaque enough. It was evidently a calcification of the crystalline lens and a partial calcification of the vitreous humor, only the median portion of which was visible. There had been a very evident increase in the calcification in the six months between the two examinations.

The possibility of such calcifications should be borne in mind for sometimes a calcified crystalline lens is mistaken for a foreign body. The differentiation between a shadow of the crystalline lens and that of an ossification or calcification of the vitreous is difficult. Both were present in this case.—*Audrey G. Morgan.*

McClelland, J. E. The syndrome of hydromicrocephaly. *J. Pediat.*, Jan., 1940, *16*, 36–51.

The term hydromicrocephaly applies to grossly small heads housing small brains with cerebral ventricles larger than normal. The term is not listed in the *Quarterly Cumulative Index Medicus* but is recognized by the *Standard Classified Nomenclature of Diseases*. The author reviews the literature back to the origin of the term in 1856. He reports his findings on 13 cases found in 142 encephalograms done on pediatric neurologic cases. Four of these cases are published in detail. All showed symmetrical dilatation of the lateral and third ventricles. Two of the 4 cases were autopsied and the dilatation of the ventricles was found to be secondary to brain atrophy. Prematurity, central nervous system infections, syphilis, and convulsions did not appear to be causative factors.

The positive findings were microcephaly, early closure of the anterior fontanelles, defective vision, mental retardation, and dilated cerebral ventricles with absence of cortical markings. The author feels the etiological factor is a prenatal defect.—*R. M. Harvey.*

ERBA, LINO. Rinolito. (A case of rhinolith.) *Radiol. med.*, July, 1939, *26*, 665–666.

The author could not find any cases of rhinolith in the Italian literature but Aberg has collected 320 cases in the world literature up to 1922. Few of these cases had been examined roentgenologically.

In the author's case the patient was a man of twenty-eight. For years he had had difficulty in breathing through the right nostril, which discharged a greenish-yellow pus with a fetid odor. Roentgen examination showed a deviation of the septum to the left. There was uniform opacity of the maxillary sinus and to a lesser degree of the ethmoid cells and the right frontal sinus. In the right nostril there was an ellipsoid shadow about 2 cm. in length and 1 cm. in breadth. It lay between the nasal septum and the middle and upper turbinates, which it had pushed outward so that it lay on the lower turbinate. The shadow was a little denser than that of bone with a clear space in the middle. It was removed by Killian's submucous resection. It was the size and shape of a large flat almond, grayish-yellow in color and with a rough, irregular surface. It consisted chiefly of tricalcium phosphate. When it was broken the clear space in the middle was found to be empty.

The author's theory is that a disc of some substance, probably cardboard, had been pushed into the nostril in early childhood, around which calcareous substance had been deposited in the course of years, and that finally the vegetable substance of the nucleus had disappeared, leaving the empty space. The maxillary sinusitis was evidently due to reaction to the presence of the foreign body and it disappeared completely.—*Audrey G. Morgan.*

NECK AND CHEST

KING, J. B. Calcification of the costal cartilages. *Brit. J. Radiol.*, Jan., 1939, *12*, 2–12.

Calcification of the costal cartilages is a subject of interest, as, with the possible exception of the pharyngeal cartilages, it is unique in showing ossification taking place throughout adult life. It is so common that it is rare to find a person of advanced years who does not show it in some degree. Calcification is rare before the age of twenty. It has, however, been established that the condition begins, on an average, at an earlier age in the male sex. It is shown that, contrary to commonly accepted views, the calcification is not perichondral, but is central and is in the nature of a true ossification.

This ossification is unrelated to disease or habitus, though disease may play a part by interfering with the normal blood calcium balance. Attempts to establish a relationship between certain diseases and this type of calcification, as apical tuberculosis and ossification of the cartilage of the first rib, have often been attempted. After prolonged study the author feels that, while a certain wide variation did exist, there was an inter-relationship between arteriosclerosis and calcification of the costal cartilages, and that cartilage ossification may be taken as a guide to the state of the vessels.

It is indicated that costal cartilage calcification is a physiological response of connective tissue to the strains imposed on it by muscular action, and it is suggested that in man, in fact, the ossification of the rib cartilages may be a reaction toward a greater rigidity of the anterior chest wall following the assumption of upright posture.

This problem needs further study although it may seem to have no practical value. But, in the writer's opinion, the finding of the presence or absence of calcification in the costal cartilages on roentgenologic examination might prove to be grounds for the diagnosis of a long standing endocrine or dietary disturbance.—*E. S. Carey.*

HASLEY, CLYDE K. Radiology's responsibility in the diagnosis and treatment of thymic hyperplasia. *J. Am. M. Ass.*, Jan. 28, 1939, *112*, 285–288.

Is the present lay concept of thymic hyperplasia based on medical facts or on medical fabrications? The unusual interest in thymic disease can be traced back to the physician, more particularly the radiologist, the pediatrician and the pathologist. The concept of mechanical obstructive respiratory death is still accepted by a few physicians, although the majority believe that death in cases of enlarged thymus and of status lymphaticus is due to cardiac failure.

No study of the chest for thymic hyperplasia is complete without a fluoroscopic study and

without films made with the patient in three or four different positions and different phases of respiration and of the cardiac cycle. In the light of present knowledge regarding the mechanical movement of the mediastinum in respiration and the various phases of the cardiac cycle, a satisfactory roentgen standard for the thymic size may never be established. Even though it were possible to establish a satisfactory normal standard it would be of but little actual value, as it overlooks the physiologic fact that the parenchyma of the gland has a secretory function which cannot be measured by size or weight.

That phase of the physiology of the thymus which may be in some way associated with the factors implicated in the shock mechanism of the body constitutes radiology's responsibility in the diagnosis of thymic hyperplasia. The shock mechanism has something to do with the reaction of the smooth muscles and the response of the autonomic nervous system. The secretory function of the thymus gland may be in some way associated with this mechanism.

To further the contention that the size of the thymus gland is a somewhat incidental finding in relation to the cause of death, the tabulated autopsy material from the Children's Hospital of Michigan is offered. Records of 116 autopsies are included in this survey. From the author's studies of these cases roentgen therapy was indicated in only a few instances. Status lymphaticus was demonstrated in only 8 per cent, and in those cases autopsy did not support the contention that the thymus actually was the cause of death. In the cases in which the thymus was largest, there were no symptoms of respiratory embarrassment. Consequently the discovery—accidental or intentional—of thymic hypertrophy does not necessarily indicate that roentgen therapy is imperative.

In only a few cases is roentgen therapy indicated and, if it is deemed advisable to try a therapeutic exposure, treatments should be given cautiously. A technique which corresponds much to that used for ordinary infection has produced the desired result. This technique has consisted of administration in one sitting of from 40 to 80 roentgens filtered through 4 mm. of aluminum, with the thyroid gland protected. The delayed roentgen-ray effects which have recently been reported in the literature are apparently due to overdosing.

In discussing this paper, Helmholz concluded that it is not known to what sudden death in childhood is due, thymic stridor must be an inspiratory and expiratory stridor, and sudden death cannot be prevented by roentgen treatment of the thymus.—*S. G. Henderson.*

Mitchell, A. Graeme, and Warkany, Josef. The problem of the thymus in children. *J. Am. M. Ass.*, Jan. 28, 1939, *112*, 283–285.

In a young infant suffering from such symptoms as respiratory stridor, dyspnea, cyanosis and dysphagia, two essential questions should, if possible, be answered. First, "Can thymic hyperplasia cause symptoms of compression?" The answer appears to be "Yes." Second, "Is thymic hyperplasia a frequent cause of the syndrome?" The answer is "No"—or, to paraphrase in the idiom of Chevalier Jackson, "All is not thymus that chokes." Thymic stridor should be noticeable in inspiration as well as expiration. It should be continuous, diminishing only moderately during rest and sleep. A purely inspiratory stridor may be congenital, due to softness and smallness of the infantile larynx, and may be intermittent. A loud and snoring inspiration is heard in retropharyngeal abscess, cysts at the base of the tongue, glossoptosis, congenital macroglossia or the macroglossia of hypothyroidism. In older children adenoids frequently cause noisy respiration. Cyanosis in thymic hyperplasia may be due to the imperfect aeration caused by tracheal stenosis or to compression of the large vessels. Cyanosis of the newborn may be due to a number of other causes, such as congenital heart disease, cerebral abnormalities or injuries and atelectasis. Dysphagia could be caused by pressure of an enlarged thymus on the esophagus. Mitchell and Brown have particularly emphasized the fact that an infant or child who has some cause for dyspnea, cough and cyanosis (as infection of the respiratory tract, congenital heart disease or the like) and who also has an enlarged thymus is more liable to these compression symptoms. Radiation treatment is not indicated simply because the thymus appears on the roentgenogram to be enlarged. No harm should result from one to three radiation treatments properly given.

Status thymicolymphaticus has nothing to do with thymic stridor. Paltauf's original paper dealt with children and adults who died suddenly, without preceding stridor or any other symptoms of disease. In some of these patients Paltauf saw at necropsy the following uncharac-

teristic symptoms: pallor, well developed deposits of subcutaneous fat, an enlarged spleen, signs of rickets and enlargement of the lymph nodes and of the thymus. The somatic makeup of these children was termed "lymphatic constitution." Sudden death still occurs in children in whom necropsy shows enlargement of the thymus gland and spleen and numerous large lymph nodes and follicles. Various investigations have made it evident that the involuted thymus of the chronically sick and undernourished child had been incorrectly considered normal, whereas the prominent thymic and lymphatic tissue of the healthy, well developed infant had also incorrectly been considered abnormal. In the majority of instances of sudden death in infants, well developed thymus glands and lymphoid tissues were declared abnormal because they were compared with the same tissues in children who had died after a wasting disease. In considering the problem of the thymus as an endocrine organ, experiments of Rowntree and Einhorn have shown that in the offspring of thymectomized rats a definite retardation of growth occurs, as reflected in body weight and in body length. Intraperitoneal injections into rats of a thymus extract produced acceleration of growth and development of their offspring. Present knowledge of the possible endocrine functions of the thymus offers nothing of practical help in treatment. The authors conclude that radiation treatment, carefully given in proper dosage, is a justifiable procedure when the thymus gland is suspected as the cause of such symptoms and when no other cause can be found.—*S. G. Henderson.*

HOSEN, H. Thyroid deficiency in twins. *J. Pediat.*, Feb., 1940, *16*, 210–214.

The author classes as a potential thyroid-deficient mother one who exhibits evidence of thyroid failure during pregnancy due to the added burden of the embryo but who has normal thyroid function before and after pregnancy. Theoretically a congenital thyroid-deficient child can only be born from a thyroid-deficient mother. In twins born of such a mother there is a greater chance of at least one inheriting the deficiency. The present article reports 3 such cases, in which one of a pair of identical twins is normal and the other thyroid-deficient. The affected twin in each case showed retarded mental and physical development. The differential diagnosis from such conditions as cerebral injury, rickets, scurvy, syphilis, myotonia, and idiocy was made entirely on the delayed appearance of the epiphyses and ossifying centers. In all sets the normal twin showed average epiphyseal development.—*R. M. Harvey.*

LINCOLN, E. M., SMITH, C. H., and KIRMSE, T. W. Subacute pneumonia in children. *J. Pediat.*, Jan., 1940, *16*, 1–17.

The authors describe a subacute form of pneumonia, frequently associated with upper respiratory infections and running a subacute or prolonged course. The characteristic roentgenographic picture is that of an irregular area of density extending from the hilar areas along the cardiac borders, across the diaphragm, and obliterating the costophrenic sulci. The shadow is not as dense as in lobar pneumonia, and exaggerated trunk and vessel markings may be seen through it. In the lateral view the lesion is usually retrocardiac. The prognosis is excellent in respect to life but the severer cases frequently go on to bronchiectasis. Treatment consists in promotion of drainage of the upper respiratory tract early in the disease by nasal instillation of vasoconstrictors, with postural drainage of the lung after the acute infection has subsided, and bronchoscopic drainage in the severe cases if required.

Differential diagnosis lies between bronchiectasis, tuberculous bronchopneumonia, and bronchosinusitis.—*R. M. Harvey.*

COHEN, ABRAHAM G., and WESSLER, H. Clinical recognition of tuberculosis of the major bronchi. *Arch. Int. Med.*, June, 1939, *63*, 1132–1157.

The authors are amazed at the slight interest that has been given to tuberculous involvement of the trachea and major bronchi.

These involvements are always secondary to other tuberculous localizations usually open lesions, though in children possibly involved lymph nodes. Abstracts of 20 case records are given. Several facts appear to be demonstrated by them: Ulcerations and stenoses may be present without noteworthy symptoms. Persistent findings of tubercle bacilli in patients alleviated of symptoms by collapse therapy should prompt the consideration of tuberculous ulcerations in unsplinted bronchi; rhonchus breathing or wheezing should signify scarring

contractions of bronchi in these patients. These contractions may reach the stage of atelectasis and in cases of pneumothorax, there may be clinical evidence of fall in intrapleural pressure regardless of maintenance of the air injections. Marked dyspnea may occur. The atelectasis may be due to extrinsic pressure—by lymph nodes, for instance (as in cases of epituberculosis). These considerations emphasize the value of bronchoscopy—to distinguish actual tuberculous ulcerations and identify atelectases due to them from those of extrinsic lesions.

These studies were of too short a time to warrant opinions as to prognosis but the authors believe that patients with this complication usually do poorly. Occlusion rather than dilatation would seem to be indicated. However, narrowing cannot be effected by mechanical means; unfortunately it has not been possible, at least in human beings, to produce such a complete closure of a bronchus by means of escharotic agents.—*A. A. de Lorimier.*

Hunt, Luke W. Roentgenograms of the chest and the intracutaneous tuberculin test for adults. *Arch. Int. Med.*, July, 1939, *64*, 49–56.

It is generally agreed that the qualitative tuberculin test (with dilutions commonly used) is of value in establishing diagnoses of tuberculosis for infants and very young children and that it is of extremely limited value for adults. The authors believe that the quantitative factor, or the measure of the degree of hypersensitivity to tuberculin, has been greatly neglected. This study was directed toward establishing a point above which reactions can be obtained only in those who possess a considerable degree of hypersensitivity—persons actively combating the disease.

A group of 505 young adults was studied with different dilutions of old tuberculin and the results were compared with roentgen evidence of past or present tuberculous infections in the lungs. Correlations were meaningless with the use of dilutions of 1:1,000, 1:5,000, and 1:10,000. However, with 1:100,000, 96.7 per cent of 230 whose roentgenograms were negative gave a negative reaction, while 3.3 per cent gave a positive reaction. Using this same dilution, 94.8 per cent of 43 who had positive roentgen evidence gave a positive reaction, and only 5.2 per cent gave a negative reaction. "Positive" reactions showed dimensions of 10×10 mm. or larger; induration was considered important—erythema alone being unreliable. With these provisions, the authors consider the quantitative intracutaneous tuberculin test to be a valuable aid when used in conjunction with other available data—its accuracy when it is properly performed and interpreted is comparable to that of the commonly accepted immunological and serologic diagnostic procedures.—*A. A. de Lorimier.*

Cole, George C. Structural changes in the lungs of drug addicts. *Arch. Int. Med.*, Nov., 1939, *64*, 1039–1052.

Roentgen chest studies were made on 674 male drug addicts of the Rikers Island Hospital.

The author reports abnormal findings in 86.5 per cent of these; 30.7 per cent were captioned "hypertrophic emphysema"; 13.94 per cent, as "emphysema without increased markings"; 4.74 per cent, as "increased markings without emphysema"; approximately another 28 per cent showed minor degrees of emphysema. About 7.0 per cent showed tuberculous lesions; about 0.5 per cent, pleural thickening and calcification. These abnormal pulmonary findings appeared to be more pronounced in patients when the studies were conducted during the height of the period of withdrawal of drugs. In order to evaluate these findings in relation to upper respiratory tract infections, careful clinical studies were conducted on 100 patients. Only 30 per cent showed abnormalities such as deviated septums, dental caries, diseased sinuses, enlarged and diseased tonsils, chronic pharyngitis and gingivitis.

The author interprets these studies as indicating that drugs such as morphine, cocaine, heroin, opium, laudanum, cannabis, etc., are directly concerned with changes in the lungs, particularly with emphysema, and accentuation of pulmonary markings. He refers to Brunelli's experimental studies which seemed to indicate that after high dosages of morphine there results an increase in capillary permeability and a tendency for pulmonary colloids to absorb water (aided by a decrease in the osmotic pressure of the blood). This theory would seem to explain the prominent markings as would also the theory of Lousida, who showed that an intravenous injection of morphine produced an increase of pressure in the pulmonary artery and an increase in the volume of blood in the lungs.—*A. A. de Lorimier.*

COHEN, ARCHIBALD C. Incidence of pulmonary and extrapulmonary tuberculosis in anthracite coal miners. *Arch. Int. Med.*, June, 1939, *63*, 1117–1122.

In 1934, a survey of the anthracite region of Pennsylvania by the U. S. Public Health Service indicated that "20 percent of miners and mine laborers over the age of 55 had clinical tuberculosis."

The authors have studied the incidence of various types of tuberculosis among 50 cases of anthracosilicosis and 84 patients with non-anthracosilicotic pulmonary tuberculosis. Only 20 per cent of the first group showed intestinal tuberculosis whereas in the latter group, 51 per cent showed lesions. Only 6 of the anthracosilicosis cases were under thirty and of these, 4 (67 per cent) had intestinal involvement; among the non-miners, 29, or 58 per cent, showed the intestinal lesions. Among the miners, 27 per cent showed laryngeal lesions, while among the non-miners the incidence was 31 per cent—the extent of pulmonary tuberculosis was much more severe among the miners. Thirty-two per cent of the miners showed tuberculous lesions of other organs as compared with 46 per cent of the non-miners.

The authors conjecture that the relative infrequency of extrapulmonary tuberculosis in the presence of anthracosilicosis is due to the extensive fibrosis and relative avascularity of the lung and the chronicity of the pulmonary tuberculosis usually present in these patients.—*A. A. de Lorimier.*

ZUBIANI, GIULIO. Le modificazioni del disegno radiografico polmonare da azioni farmacodinamiche. (Changes in the roentgen image of the lung outline from pharmacodynamic action.) *Radiol. med.*, July, 1939, *26*, 652–663.

The author reviews the normal appearance of the lung outline in the roentgenogram and discusses the effect on it of various drugs, particularly histamine. The action of drugs on the pulmonary circulation frequently differs from that on the general circulation. Adrenalin may have a vasodilating rather than a vasoconstricting action. Cholin and acetylcholin have only a very slight vasodilating action on the vessels of the lungs, but they have an intense action on the bronchial musculature, sometimes to such an extent as to cause asthmatiform attacks. Pituitrin causes energetic contractions of the bronchial muscles and pulmonary vessels. Atropin, pilocarpin eserin, ergotamin and nicotine do not have any appreciable specific effect on the lungs. Ephedrin dilates the bronchi. The author studied the action of histamine by giving subcutaneous injections of 1 mg. imido, Roche. The first examination was made four minutes after the injection and after that roentgenograms were taken every three minutes until pulse and respiration were restored to normal. This occurred ordinarily in from ten to fifteen minutes, but in some cases of decompensated heart lesions not until after three-quarters of an hour. Even in normal individuals there was a phase of hyperaeration of the lungs immediately after the injection and a moderate increase in the hilar shadows which lost their usual sharp outline. The vessel shadows became more marked for a time and showed a large-meshed network. Two roentgenograms are given of the case of a young man of twenty-seven with a mitral and aortic valve lesion resulting from rheumatic endocarditis. Blood pressure underwent a moderate increase and the pulse increased from 108 one minute after the injection to 120 fifteen minutes after. Dyspnea and cyanosis developed and there was a progressive increase in the opacity of the lung fields because of the transudation that occurred from even the large vessels. The large perihilar bronchi were more evident than before the injection and somewhat dilated. Among the subjective symptoms were cough and foamy expectoration probably due to congestion from a certain amount of edema of the lungs. The hyperemia was almost exclusively arterial. The roentgen picture was very much like that of congestion of the lungs from decompensated heart lesions, although the valve lesions were compensated in this case. The picture indicates that there is an active regulation of the pulmonary circulation, and it shows the importance of the pulmonary circulation in producing changes in the roentgen image of the lung outline.—*Audrey G. Morgan.*

GIORDANO, GIOVANNI. Cisti da echinococco con immagine da scollamento. (Echinococcus cyst with detachment.) *Radiol. med.*, Aug., 1939, *26*, 765–766.

A woman of thirty-two in October, 1938, suddenly had intense pain in the lower posterior half of the left side of the thorax, with no fever but with a dry cough at intervals. A physician diagnosed it as pleurisy and gave the usual

treatment. After about two months the pain persisted and the sputum was streaked with blood.

Roentgen examination of the thorax showed a round shadow the size of a large orange in the lower third of the left lung field; it was quite regular in outline and its upper pole was surrounded by a semilunar transparent zone which in turn was bounded above by an opaque ring. The diaphragm on this side was movable normally and the sinuses were free. The shadow did not show any change in outline or form on respiration. A diagnosis was made of echinococcus cyst in the left lung with detachment.

The preliminary operation consisted of resection of segment of the 8th and 9th ribs. Three days after this, vomica was expelled which contained shreds of membranes and typical hooks. Another roentgen examination showed that the cyst had been transformed into a cavity containing air and water.

The picture of detachment was caused by the penetration through a bronchiole of air into the virtual cavity between the cyst and the lung tissue. The line of separation between the opaque zone and the curved transparent zone which was fixed and had its convexity turned toward the transparent zone differed from that seen in a cavity filled with air and water, as the latter has a horizontal boundary which oscillates and changes with change in position. This image of detachment of the cyst is quite rare. It is said to occur in only 2 to 3 per cent of cases. It is seen usually in large cysts which are about to rupture.—*Audrey G. Morgan.*

Lura, Antonio. Modificazioni di grandezza e di forma dell' ombra cardiaca in alcuni casi di tbc. polmonary cronica. (Changes in the size and shape of the heart shadow in some cases of chronic pulmonary tuberculosis.) *Radiol. med.*, Sept., 1939, *26*, 838–844.

While it is true that in pulmonary tuberculosis the size and shape of the heart is that corresponding to the constitutional type of the patient, yet there are changes in the heart shadow directly due to the lung disease. Etienne Bernard has suggested the name of secondary drop heart for the heart in chronic pulmonary tuberculosis. He says that it is a progressive decrease in the size of the heart which takes place gradually with the margin of the shadow straight and a certain tendency to displacement upward of the heart. He says that the small size of the heart is only apparent and due to the displacement of the heart upward and toward the anterior wall of the thorax and to a partial rotation of the heart on its own axis during which the apex moves to the right.

The author discusses the heart shadows he has seen in many cases of pulmonary tuberculosis, describing a number of them and illustrating them with roentgenograms. He, too, found a progressive decrease in the size of the heart shadow which had rectilinear outlines. He disagrees, however, with Bernard in the description of this shadow. It is not a drop heart but a geometrical or cubist heart. The shape of the shadow is that of a trapezium. And it is caused not by the displacement of the heart upward and rotation on its axis but by adhesion between the pericardium and pleura. The inflammation is on the outside of the pericardium; there is no endocarditis or effusion. The inflammation extends to the pleura and causes firm adhesions between them. If the adhesion between the pericardium and pleura is not complete the outline may be only partly rectilinear, the part where there is no symphysis preserving its curved outline.—*Audrey G. Morgan.*

Berk, Louis H. Roentgen diagnosis of mural thrombi. *Arch. Int. Med.*, June, 1939, *63*, 1183–1189.

The author was able to find reports of 5 cases in the literature where mural thrombi were recognized antemortem and later proved by postmortem studies. He is reporting another such case which showed densities due to calcifications in mural thrombi in the mitral valve and in the pericardium.

Most mural thrombi are located in the left auricle and they are associated with mitral stenosis. Calcifications of them are usually round or semilunar and sharply outlined. They show a dancing motion as do valvular calcifications, but the latter are characteristically much smaller. Noncalcified thrombi may be visualized as denser shadows than the adjoining cardiac silhouette but as such they are seldom recognized unless there are marked changes in contour.

In differential considerations the following generalities are stated: calcified valves—situated more medially than calcified coronary arteries. Calcified mitral valves are usually to the left of the spine (as projected in the anteroposterior view) and near the posterior cardiac

wall (as shown in the left anterior oblique view). Aortic valves are located low at the left border of the spine and almost in the middle of the silhouettes (left anterior oblique position). These calcifications are usually semilunar in outline. In the case of mitral calcifications the pulsation movements are usually toward the apex; the aortic calcifications show more of a dancing motion.

Calcified cardiac aneurysms are usually large and located near the apex. A strong systolic pulsation is the rule.

Pericardial calcifications are more apt to be streakings near the right ventricle or near the coronary sulcus. They usually show very little pulsation. With rotation of the patient these calcifications may be shown to parallel the outline of the heart.

Calcified costal cartilages are denser and careful study will identify them by their course. Calcified glands, calcifications in the lungs should be easy to identify by rotation of the patient and by their movements with respiration.—*A. A. de Lorimier.*

MEYER, A. Kymography as an aid in the differential diagnosis of mediastinal tumours. *Brit. J. Radiol.*, July, 1938, *11*, 436–443.

Kymography has been found to be of value in the differential diagnosis of mediastinal neoplasm and aortic aneurysm in addition to the investigation of heart disease. The following points serve in the differentiation.

Movement which is indicated by notching of the outline. Aneurysms tend to show movement while new growths do not.

Timing—Aneurysms tend to show movements in phase with aortic pulsations, while new growths tend to show a time lag. This is calculated by direct measurements from the slat markings.

Character of the outline—That portion of the aneurysm which is pulsating will give a characteristic outline, a horizontal upper and a sloping lower margin. This is the aortic type of tracing. New growths by virtue of their close proximity to the aorta and of their own vascularity never pulsate homogeneously and do not tend to produce the characteristic aortic outline. The outline is either a sloping upper and lower margin or a rounded outline.

Relationship to aortic outline—The outline of an aneurysm tends to merge with the outline of the aorta, whereas the moving wall of the aorta can generally be seen through the shadow cast by the new growth.—*E. S. Carey.*

ABDOMEN

BACCAGLINI, MARIO. Contributo radiologico allo studio dell' ulcera della grande curva gastrica. (Roentgen contribution to the study of ulcer of the greater curvature of the stomach.) *Radiol. med.*, Sept., 1939, *26*, 811–825.

Ulcer of the greater curvature of the stomach is rare. Nevertheless the possibility of its existence should always be thought of when examination for ulcer at the most usual sites proves negative. Roentgen examination makes it possible to detect even small ulcers of the greater curvature and for the most part to differentiate between benign and malignant forms. A careful study of the mucous membrane relief is of great importance in this differentiation.

The author gives a table reporting 24 cases of ulcer of the greater curvature from the literature and describes in detail 6 cases of his own with illustrative roentgenograms. Among 5,000 cases of ulcer of the stomach which he examined only 6 were on the greater curvature, that is only a little over one in a thousand. The site of predilection is the descending part of the greater curvature, especially the middle and upper thirds.

The technique of roentgen examination for these ulcers is the same as that for examination of the digestive tract in general, special stress being laid on examination in various positions and projections with varying degrees of filling of the stomach and on very detailed study of the mucous membrane relief.

The direct and most reliable sign of ulcer of the stomach at any site is a niche at the place where the ulcer is located. The indirect signs are spasm and incisure with a large radius around the niche. In ulcer of the greater curvature there is apt to be retraction of the wall around the niche. Irritation around the ulcer often produces spasm of the opposite side of the stomach wall. The mucosa varies in appearance depending on the stage of the ulcer—active, cicatricial or malignant degeneration, and a careful study of these variations aids in differential diagnosis. Irritation in ulcer of the greater curvature may cause spasm of the greater curvature itself around the ulcer.

Pressure from neighboring organs, such as the colon or spleen, may simulate ulcer niche, but differentiation is possible by examination in

different positions and manipulation designed to separate the shadows of these organs from that of the stomach.

The percentage of small ulcers in the author's cases was much greater than in the usual statistics and the percentage of perforations less, probably due to the fact that the diagnosis was made earlier than usual. He emphasizes the importance of repeated careful examination to determine whether the image is fixed as in niche or variable as in the case of barium caught in the mucous membrane folds and sometimes simulating niche.—*Audrey G. Morgan.*

Anzilotti, A. Evoluzione maligna di una gastrite ipertrofica. (Malignant course of a hypertrophic gastritis.) *Radiol. med.*, Sept., 1939, *26*, 863–864.

On Dec. 16, 1933, a woman thirty-nine years of age who had suffered for a long time from hyperacid dyspepsia was sent for roentgen examination with a diagnosis of ulcer. The examination showed instead a hypertrophic gastritis. She improved and was well until 1936 when one day after having drunk a large amount of wine she vomited and this was followed by moderate hematemesis. She was reexamined Aug. 5, 1936. In addition to the hypertrophy of the mucous folds seen before, there was a central pyriform lacunar image which was interpreted as a pedunculated polyp of the stomach. This explained the hematemesis, and operation was advised but the patient refused it.

On Feb. 15, 1939, she was again sent for examination because for two or three months she had had continuous pain in the epigastrium, increasing after meals; she also complained of loss of appetite, weakness and recently vomiting. A resistance was palpated in the epigastrium which suggested tumor. Roentgen examination showed an antral filling defect with all the characteristics of malignancy. Operation showed a cancer involving the greater part of the pyloric region, adherent to the pancreas and infiltrating the gastrocolic and gastrohepatic omentum, with many gland metastases. The patient died soon after the operation.

This case confirms Konjetzny's idea that hypertrophic gastritis frequently results in cancer. The sequence: hypertrophic gastritis—polypous gastritis—cancer is frequent and operation should always be advised in polypous gastritis following hypertrophic gastritis.—*Audrey G. Morgan.*

Fugazzola, Franco. Sulla funzionalità del duodeno in alcune malattie gastriche. (Function of the duodenum in some diseases of the stomach.) *Radiol. med.*, Oct., 1939, *26*, 907–926.

The author briefly reviews the anatomical facts in regard to the innervation of the stomach and duodenum, showing that they are innervated from the celiac plexus. He then describes and illustrates with roentgenograms numerous cases of atony and dilatation of the bulb of the duodenum in patients with ulcer or cancer of the stomach. There is no doubt that there is a functional unity of the different segments of the digestive tract, particularly of the segments that have a common vago-sympathetic innervation. There are a number of other conditions aside from cancer and ulcer of the stomach that cause atonic stasis of the duodenum, such as chronic mesenteritis, enlargement of the mesenteric glands, acute and chronic peritonitis, acute and chronic pancreatitis and periduodenitis. Periduodenitis may cause adhesions which bring about actual anatomical changes leading to variations in motility and tonus of the bulb of the duodenum. Such alterations may also be caused by acute inflammations of the appendix and intestine. The detection of such changes in the motility and tonus of the duodenum and of their causes requires careful serial roentgenography.

After a detailed discussion of the causes of these changes, the author concludes that while some of them may have an actual anatomical causation the majority are due to changes in neurovegetative innervation.—*Audrey G. Morgan.*

Colosimo, Cesare. Corpi estranei nel duodeno. (Foreign bodies in the duodenum.) *Radiol. med.*, Sept., 1939, *26*, 845–856.

In spite of the progress in the roentgen localization of foreign bodies in the digestive tract, many mistakes are still made in diagnosis, particularly if the bodies are transparent to roentgen rays, and when symptoms do not follow immediately on the swallowing of the body. When symptoms do develop the patient may have forgotten the swallowing of the body.

Foreign bodies in the duodenum are generally elongated, rigid and not plastic. The author

describes a case in a young man of twenty-two. He entered the hospital in November, 1937, because he had been suffering for about three months from acidity, burning sensation and epigastric pain. The symptoms were those of duodenal ulcer with partial stenosis. Roentgen examination of the digestive tract showed a large bulb of the duodenum with a large round central defect of filling the size of a quarter. In the center of it there was a round, very opaque spot the size of a small hazelnut. On manual expression of the first part of the duodenum, the small hyperopaque image remained fixed near the base of the bulb while the defect of filling rose to the upper flexure but did not pass it. The opaque shadow looked like a niche and, because of this and the clinical symptoms, a diagnosis of duodenal ulcer was made and the patient sent to a surgeon.

On operation a peach seed was found in the duodenum; it was the cause of the filling defect. There was also an ulcer from decubitus which had caused the opaque shadow. Uneventful recovery.—*Audrey G. Morgan.*

NUZZO, LUCIANO. Un caso di tubercolosi stenosante del digiuno. (A case of stenotic tuberculosis of the jejunum.) *Radiol. med.*, July, 1939, *26*, 664–665.

The patient, a woman of fifty-five, did not have any history of any importance except that two children had died of tuberculosis. For about three months she had had a feeling of weight in the epigastrium after meals, without true pain and without acidity or pyrosis. Later vomiting developed four or five hours after meals; it was alimentary and acid. No hematemesis or pyrosis. Slight weakness and emaciation. Good appetite.

Roentgen examination showed the first loop of the jejunum moderately dilated with marked valvulae conniventes and a constriction below it. Operation showed that the stenosis was due to infiltration which was at first thought to be due to a new-growth of the first loop of the jejunum 40 cm. from Treitz's ligament with some enlarged lymph glands in the mesentery. Resection was performed, extending from 10 cm. above to 10 cm. below the stenosis, followed by end-to-end suture of the loop and removal of the lymph glands. Roentgen examination showed perfect canalization of the intestine. Recovery was uneventful.

Tuberculous stenosis is seen more frequently in the primary than in the secondary stage of tuberculosis; this case is worth publishing because of its rarity.—*Audrey G. Morgan.*

ANZILOTTI, ALBERTO. L'ileite regionale iperplastica-ulcerosa. (Hyperplastic ulcerous regional ileitis.) *Radiol. med.*, Aug., 1939, *26*, 685–719.

Most of the literature in regard to inflammations of the ileum is concerned with tuberculosis and other granulomata and tumors. Until recent years little or nothing had been written about nonspecific inflammations. In 1932, however, Crohn, Ginzburg and Oppenheimer described a form of ulcerous hyperplastic inflammation of localized parts of the ileum. They described 14 cases and since then the number of American cases has increased to 500 and the European cases to about 100. There are various theories as to the cause of the condition but no causative microorganism is known. The definition of the disease is "a chronic hyperplastic ulcerous nonspecific inflammation involving all the layers of the intestinal wall and the mesenteric glands limited to the terminal part of the ileum, stopping at the valve of Varolius and sparing the cecum." Some cases, however, are chronic from the beginning and some pass through an acute stage before becoming chronic.

The clinical picture in the acute stage is quite like that of an acute perforated appendicitis. The subacute and chronic stages resemble recurrent invagination, ileocecal tuberculosis, ulcerative colitis or carcinoma.

Correct diagnosis depends largely on thinking of the possibility of this condition. If it is known there are signs by which it can be differentiated from other diseases. The author describes 2 cases of his own; in the first the diagnosis was not made because of lack of knowledge of this picture; in the second the diagnosis was made without difficulty. He also describes a third case in which there was no surgical control because of the age and poor general condition of the patient. The terminal symptoms are colic, mucohemmorhagic diarrhea and a continuous-remittent fever. There is also a rapid decline of the general health, which may even resemble a true cancer cachexia.

The roentgen picture shows a deformed, cord-like appearance of the affected loop of the ileum. This has been called by American authors the string sign or twisted cord sign. There

is dystonia and dilatation of the loop above the affected one. The mucous membrane relief is greatly changed; the valvulae conniventes disappear and there are folds with an abnormal course in the affected loop. In the terminal stage the mucous membrane relief disappears entirely. Segmental atony is characteristic of the disease. In the terminal stage there are fistulae resembling those of actinomycosis. Usually the cecum and colon are normal. The only effective treatment is surgical.—*Audrey G. Morgan.*

Marzocchi, Gualtiero. Il transito del pasto opaco nel colon in condizioni normali. (The passage of opaque paste into the colon under normal conditions.) *Radiol. med.*, Oct., 1939, *26*, 927–949.

The author has made a roentgen study of the passage of the opaque medium through the intestine. He gives a series of diagrammatic drawings of the passage of the paste in males and females and a table showing the sex and morphological type of the patients, the time of the first and last evacuations and the position of the cecum, transverse colon and the right and left flexures. He studied 30 normal subjects, 15 male and 15 female.

He found that normal subjects have a daily evacuation. This evacuation, however, is not sufficient to empty the whole of the large intestine but only empties the distal part of it, the sigmoid and rectum. The total elimination of the opaque column requires sixty-five hours on an average, the time varying from a minimum of twenty-nine hours to a maximum of 118. The number of evacuations necessary to empty the whole of the large intestine varies from two to five with a normal average of three. The intestine of the female is somewhat more torpid than that of the male and requires on an average fifteen more hours for complete evacuation. In normal individuals there is an evident correlation between the emptying time and the morphological type of the subject. The large pendulum-like movements described by Rieder seem to be of considerable value in emptying the cecum and ascending colon and in the progress of the opaque column in general.—*Audrey G. Morgan.*

Guidotti, Carlo. Pancreas accessorio della parete duodenale e sua immagine radiologica. (Accessory pancreas of the wall of the duodenum and its roentgen image.) *Arch. di radiol.*, Jan.–Apr., 1939, *15*, 34–36.

The patient, a woman of twenty-five, had suffered for some years from gastric disturbances, consisting of dyspepsia, burning pain when the stomach was empty, acid eructation and sometimes vomiting, no icterus, constipation but no blood in the feces. Examination of the stomach contents showed hyperchlorhydria which increased greatly on taking histamine; blood examination showed 3.5 million red cells and 10,000 leukocytes with a moderate lymphocytosis, 26 per cent.

Roentgen examination showed the stomach normal. The bulb of the duodenum showed a deformity in the middle recess the shape of a finger-nail. It was constant in all the positions in which the patient was examined. The conclusion from the roentgen examination was that the deformity was due either to an old ulcer or a beginning tumor, to the results of periduodenitis caused by cholecystitis or to pressure from a calculus in the gallbladder or a retroperitoneal mass of glands.

Operation showed a small subserous nodule the size of a small hazelnut which proved on histological examination to be made up of typical pancreatic tissue.

The author has found only 2 similar cases in the recent literature and in both of these the accessory pancreas was in the stomach.—*Audrey G. Morgan.*

GYNECOLOGY AND OBSTETRICS

Massari, Gian Maria. Fistola vescico-ileale. (Ileovesical fistula.) *Radiol. med.*, Sept., 1939, *26*, 865–866.

A woman of fifty-seven was operated on for cancer of the bladder. It was so extensive that nothing could be done except a simple exploratory cystotomy. About two months after the operation the patient passed some fecaloid cylinders from the urethra. Cystoroentgenography showed a filling defect with irregular outlines in the anterior and right wall of the bladder, and a delicate fistula connecting the bladder, with a loop of intestine passing from right to left and a little upward. It appeared to be a loop of small intestine. An opaque enema was given and the appearance of the loop was such that it was believed to belong to the ileum.

The patient died three months later and autopsy showed that the loop was really a part of the ileum.

Vesico-intestinal fistulas are not extremely rare but only 10.40 per cent of those reported have been with the ileum, 34.70 per cent with the rectum and 24.42 per cent with the sigmoid and colon. Of all the cases reported none before has been caused by cancer of the bladder.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

MUSCETTOLA, GUISEPPE. Raro caso di pseudocalcolo trasparente intrauretero-pelvico in uretero-pielografia. (Unusual case of transparent intrauretero-pelvic calculus in ureteropyelography.) *Radiol. med.*, Aug., 1939, *26*, 767–769.

Ureteropyelography has been considered the best method of demonstrating uretero-pelvic calculi which do not show on direct examination because they are too transparent. It should be borne in mind, however, that the same image may be produced by other causes, among them air-bubbles introduced through the syringe and catheter.

The author described such a case in a man of thirty-two who had the typical clinical signs of calculus. The surgeon was sure, therefore, that he would find a renal, or more probably a ureteral calculus, but he practiced a ureteropyelography for the purpose of determining the condition of the intrarenal excretory ducts and for determining the exact site of the calculus. The roentgenogram showed a moderate dilatation of the pelvis and a small round lacunar image with distinct outlines, exactly like that of a transparent calculus. Though this seemed to confirm the clinical diagnosis completely, a second roentgenogram was taken which showed a decided change. The round image had disappeared and instead of it there were four lacunar images at and above the infundibulum of the pelvis. There was no doubt that these were air-bubbles and that the first image had been an air-bubble also.

This case shows the necessity for taking great care not to introduce air in ureteropyelography and also the necessity for care in interpreting the images.—*Audrey G. Morgan.*

ANZILOTTI, ALBERTO. Esiti a distanza di un grave trauma renale. (Late results of a severe injury of the kidney.) *Radiol. med.*, Feb., 1939, *26*, 144–146.

Injuries of the kidney may cause calcification of the parenchyma or true calculi of the pelvis. Perirenal hematomata may undergo calcification.

The author describes a case in a young woman of twenty-four who suffered a violent injury of the left lumbar region. She had copious hematuria. She recovered spontaneously but had intermittent pain followed by fever which increased in intensity as time passed. The attacks of pain grew worse and the fever continuous and she was sent to the hospital.

Examination of the urine showed a few red cells and many leukocytes. Roentgen examination showed many small concretions at the lower pole of the kidney; the size of the kidney was decreased. Urography showed normal findings on the right with slight compensatory dilatation. On the left no kidney pelvis showed on the numerous roentgenograms and on only one there was a slight shadow representing the upper part of the ureter. Ascending pyelography showed normal conditions on the right and on the left, where only 2 cc. of lithium iodide could be injected, there was a small pelvic cavity above the group of concretions; the cavity was still full ten hours after the roentgenogram.

The kidney was removed with great difficulty. It was small, the shape of a banana and embedded in cicatricial tissue. The lower half was literally filled with concretions. The lower part of the pelvis and the lower calyces had completely disappeared. At the upper pole there was a small pelvic cavity communicating with a single calyx full of purulent urine and containing a few small calculi which had not appeared on the roentgenogram.

There had evidently been a rupture of the kidney with copious hemorrhage into Zuckerkandl's capsule. In spite of the great precipitation of calcium salts at the site of the pain, as shown by the intrarenal calculi, the perirenal hematoma had become organized without calcification.—*Audrey G. Morgan.*

BUISSON, M., and LOVOTTI, S. L'urografia endovenosa può essere considerata un teste di funzione renale? (Can intravenous urography be considered a test of renal function?) *Radiol. med.*, Aug., 1939, *26*, 739–765.

All students of the subject agree on the value of urography in studying the morphology of the urinary tract, but they are by no means unanimous in regard to its value as a test of kidney function. The authors believe that this difference of opinion is due to the technique used.

They describe their technique in which they inject uroselectan after having made a roentgenogram of the whole urinary tract without contrast substance, in order not only to detect any calculi or calcifications but primarily to observe the image of the kidneys which is generally visible under normal conditions. Sometimes even with this roentgenogram a difference can be detected in the two sides, one image being very distinct while the other is less so. As the visibility of the kidney is dependent on the blood circulation in it this difference suggests a functional change in one of the kidneys, though this value is not absolute. Immediately after the injection another roentgenogram is taken and still others one minute apart, so that three roentgenograms are taken within three minutes after the injection. These are examined very carefully for the purpose of detecting the exact moment when opacification of the calyces and pelves begins, and noting any difference in time on the two sides. If there is such a difference of course it indicates a difference in function on the two sides. This technique is effective in demonstrating functional changes, while the usual technique of comparing the density of the shadows of the two pelves is of no value whatever.

The authors describe and illustrate with roentgenograms a number of cases in which, in addition to this method of urography, they made physiological functional tests, such as the phenolphthalein test, concentration of urea, concentration of chlorides, etc. They conclude that in order for intravenous urography to be considered a good functional test it must run parallel with the usual urological functional tests. There are, however, cases in which catheterization of the ureters is impossible and in such cases intravenous urography alone may be considered a sufficiently reliable test.—*Audrey G. Morgan.*

Cope, Oliver, and Schatzki, Richard. Tumors of the adrenal glands. I. A modified air injection roentgen technic for demonstrating cortical and medullary tumors. *Arch. Int. Med.*, Dec., 1939, *64*, 1222–1238.

Clinical syndromes may suggest endocrine abnormalities but for actual diagnosis there is usually wanted an anatomical demonstration of the abnormal gland. The syndrome, associated with hyperfunctioning of the adrenal cortex, includes: virilism, basophilism and (in the case of males) feminization. Abnormal amounts of androgen or estrogen may be found in the urine but these findings are not usually impressive until any adrenal tumor is so large that it would be palpated. Hyperadreninism due to a pheochromocytoma cannot be distinguished from other types of hypertension. Therefore, the authors emphasize the value of visualization of the adrenals by air contrast in these cases of suspected adrenal disease.

Occasionally, air or fat emboli and other complications have been reported following injections of air into the peri-kidney and adrenal regions. However, the authors consider that their results on 163 separate injections in 78 patients warrant consideration; they believe that their particular technique has reduced the incidence of trouble and the information gained speaks for continuing these studies. They recommend it only for patients in whose cases there is definite suspicion of disease of the adrenal glands. For this they may obviate an operative exploration—which would carry a much greater risk. The following considerations were emphasized:

Preliminary studies of the abdomen and visualizations of the kidney with interest as to any abnormalities in contour or position of the latter.

Site of Air Injection: Just above the iliac crest and lateral to the border of the semispinalis.

Procedure: Procaine injection, Insert No. 20 gauge lumbar puncture needle at obliquity toward spine beginning at a point just above the iliac crest and lateral to border of semispinalis, passing through skin, subcutaneous fat, lumbodorsal fascia, quadratis lumborum muscle, anterior layer of lumbodorsal fascia, paranephric fat and finally through the posterior fold of the renal fascia into the perinephric fat. This latter position can be realized by the lack of resistance to the needle. Procaine is then injected into these tissues (repeated test by aspirations for blood).

Volume of Injection: As much as 200 cc. (air).

Rate of Injection: Ten minutes or longer should be required; pressure should not exceed 25 cm. of water.

Roentgenography—anteroposterior and lateral studies—after one-half to one hour, allowing patient to walk around (massage for distribution of gas not recommended).

Complications to be Considered: (*a*) Air embolism—2 such deaths reported by Fish; authors emphasize the importance of slow injection of air. (*b*) Hematoma of the renal cortex—should be avoided by technique of needle injection recommended—the site being much lower and more lateral than often practiced. (*c*) Hematoma of the adrenal gland. (*d*) Expression of adrenin—may result from palpation or because of sudden or excessive air pressure. (*e*) Pain—also minimized by slow injection and smallest possible quantity of air—probably an exceedingly rare occurrence.—*A. A. de Lorimier.*

SKELETAL SYSTEM

NICOTRA, ANTONINO. Indagini sulla 'familiarità" dell'anemia mediterranea o "morbo di Cooley." (Study of the familial character of Mediterranean fever or Cooley's disease.) *Radiol. med.*, Aug., 1939, *26*, 720–739.

The author studied a patient with Cooley's disease and ten members of her family, the father and mother, 3 sisters, 3 daughters and 2 daughters of one of the sisters. All of them except the father had characteristic changes in the bones which seem to occur in members of the family of patients with this disease. He believes that in this disease there is a hereditary familial or ethnic taint which becomes more marked in patients with pronounced forms of the disease. In this case the taint was evidently inherited from the mother and not from the father, and led to frank disease in only one of the daughters. The other members of the family were apparently well.

They showed, however, marked changes in the bones, both osteolytic and hyperostotic. Roentgenograms of the bones are reproduced which show rarefaction of the bones of the skull and of the joints. There was porosity of the bones of the skull, particularly in the parietal regions. Hyperostosis was manifested in the diploe by thickening of the trabeculae and consequent lessening of the size of the diploic cavities. In the external table hyperostosis was shown by the deposition of a layer of osteoid tissue on the surface of the periosteum. In the long bones there were delicate stripes formed doubtless by osteolysis along the haversian canals. In addition to the changes in the bones, there were changes in the bone marrow, the circulating blood, the liver and the spleen. These are a part of the familial taint which results in Cooley's disease.—*Audrey G. Morgan.*

GUARINI, CARLO. Xantomatosi: Sindrome di Christian-Schüller. (Xanthomatosis: Christian-Schüller's syndrome.) *Arch. di radiol.*, May-June, 1939, *15*, 334–335.

The author refers to his work on this subject published in 1938 in which he gave credit to Bianchi for having been the first to recommend roentgen treatment in Christian-Schüller's disease. Moreau in his monograph claimed that Cignolini deserved this honor. Guarini recognizes his own mistake and the correctness of Moreau's criticism and quotes from Bianchi and Cignolini in confirmation of this correction. —*Audrey G. Morgan.*

CIGNOLINI, PIETRO. La roentgenterapia della malattia di Hand-Schüller-Christian. (The roentgen therapy of Hand-Schüller-Christian's disease.) *Radiol. med.*, Sept., 1939, *26*, 826–837.

Hand-Schüller-Christian's disease is perhaps best known by this name because the names used in an effort to define it are so varied that it is hard to decide among them. It is essentially a lipoidogranulomatosis with a disturbance of lipoid metabolism. It is highly infiltrative and the lipoids accumulate in the cells of the reticulo-endothelial system.

Clinically the lipoidogranulomatous formations originate from the bone marrow and destroy the surrounding bone. The bones of the skull are most frequently involved. There are characteristic lacunar structures. But the long bones, the iliac bones, the ribs and mandible may also be involved. The disease may also involve the dura mater, the lungs, the liver and the spleen. In cases in which the disease is generalized, particularly if the liver, spleen and lymph nodes are involved, there may be changes in the blood; such changes are rare in cases in which only the bones are affected. Cholesterin is increased in the great majority of cases; the figure generally varies from 190 to 300, though as much as 1,012 mg. has been found. Any case of hypercholesterinemia is to be considered a potential case of Hand-Schüller-Christian's disease, and careful roentgen examination is indicated.

Ten years ago the author gave roentgen treatment in a case of this disease in a boy of twelve, associated with diabetes insipidus. There was great improvement in the condition of the bones, the general condition, the diabetes and the amount of cholesterin. He recommends

the use of roentgen therapy in all cases of cholesterinosis and emphasizes the value of roentgen treatment of the bones in diabetes insipidus.—*Audrey G. Morgan.*

Perlman, H. H. Chronic Gaucher's disease. *J. Pediat.*, Feb., 1940, *16*, 191–205.

According to the author there have been less than 150 cases of chronic Gaucher's disease reported in the literature. He reports the case of a five year old child with an enlarged spleen and liver, and a moderate secondary anemia, who was first seen in 1932 with an acute upper respiratory infection. The patient was followed until his death in 1939 at the age of twelve. Liver function tests were normal at all times. The height-weight ratio was normal until the age of nine at which time a definite lag began. At the age of twelve the patient was 3 inches below average height and 13 pounds under the average weight. Death was due to pulmonary embolism following splenectomy.

The following findings were noted on roentgenological examination at various dates:

May 4, 1933—1. Irregular areas of density in neck of right femur associated with areas of rarefaction and a coxa vara deformity. 2. Periosteal reaction along femoral shaft. 3. Erlenmeyer flask shape of lower ends of both femora.

Sept. 6, 1933—1. Increased rarefaction in neck of right femur with increased coxa vara deformity. 2. Enlargement of medullary canal with thinning of cortex in upper shaft of left femur.

Feb. 14, 1934—No change in either femur.

April 11, 1939—1. Typical Erlenmeyer flask appearance of distal ends of both femora. 2. Numerous transverse trabeculations throughout shafts of both femora and tibiae due to previous growth arrest. 3. Infiltration of marrow cavity in lower ends of shafts of both humeri, radii, and ulnae. Generalized rarefaction of hands, wrists, jaws, and ribs.—*R. M. Harvey.*

Moller, P. F. Chronic fluorine poisoning, seen from the roentgenological standpoint. *Brit. J. Radiol.*, Jan., 1939, *12*, 13–20.

Chronic fluorine poisoning in man was not known until 1931, when, in the course of some investigations for silicosis in factory workers, the author discovered some curious changes in the bones of a number of workers engaged in a cryolite factory.

The symptoms correspond both clinically and pathologically with those previously found in animal experiments. Cryolite, which is a fluoride of sodium and aluminum, contains about 54 per cent fluorine. Investigations showed that it was the swallowing of the dust that resulted in poisoning because fluorine absorption takes place almost entirely through the intestine, while no absorption takes place through the lungs.

The clinical symptoms were lack of appetite, nausea, and vomiting. Over 80 per cent suffered from one or more of these. That these symptoms were dependent upon the dust laden atmosphere was evident from the fact that these symptoms were of an acute nature and disappeared when the worker came out into the open air. One-third complained of intestinal symptoms, chiefly chronic constipation. Fifty per cent had chest symptoms, dyspnea upon exertion, cough and expectoration. A little over 33 per cent complained of localized or indefinite pains of a rheumatic character in the body or extremities or general body stiffness. But the principal signs of the poisoning were the changes in the bones. On roentgen examination of the spine and pelvis, there is noted almost complete disappearance of normal bony structure, which has been replaced by an almost absolute milky white opacity. The isolated trabeculae appear very thick, dense and of a woolly indistinctness. The outlines of the vertebrae lack sharpness and the transverse processes are wide, thick, and covered with small excrescences, and the spinous processes shine through as a dense irregular band. The ligaments on the anterior and lateral aspects of the vertebral bodies may be calcified and form actual bridges between the bodies. Posterior ends of the ribs are covered along the edges with large irregular excrescences resembling hoar-frost needles. There occurs a calcification in the ligaments, fibrocartilage, and at the points of attachments of the muscles.

In severe cases all the bones are affected, but in most cases the pelvis and vertebrae show the most pronounced changes. The degree of sclerosis depends on the length of time the subject has been engaged in the dusty work. The first stage is observed at the earliest after two and a half years, the second after from two to four years and the third after eleven years.

The author describes also the findings in animals, and means of poisoning other than industry such as through water supply, food-

stuffs, and plants grown in fluorine atmosphere eaten by animals which in turn are eaten by man. Changes known as "mottled teeth" supposedly due to fluorine poisoning are also described.—*E. S. Carey.*

AGATI, DINO. Cisti giovanili essenziali della clavicola. (Idiopathic cysts of the clavicle in young subjects.) *Arch. di radiol.*, Jan.–Apr., 1939, *15*, 5–16.

Idiopathic cysts of bone are not extremely rare. The bones most frequently involved, however, are the upper end of the humerus, the tibia and the femur, more rarely the fibula and the bones of the forearm. Involvement of the clavicle is very rare.

The author describes 2 cases of cyst of the clavicle, diagnosed by roentgen examination, one in a boy of fifteen and the other in a boy three years of age. The lesion in both cases was located in the distal end of the clavicle, did not interfere with the function of the arm and only in the second case caused slight pain. In the first case the patient had suffered a slight trauma of the arm about fourteen months before. In the first case subperiosteal resection of the affected part of the bone was performed. Healing was by first intention. Forty days later roentgen examination showed reconstruction of the bone. In the second case the treatment was not carried out by the author and he does not know its exact nature, but the child was in excellent health eight years after the appearance of the cyst.

In the early stages of these cysts the roentgenogram shows an expansion of the affected part of the bone with a clear space in the center of it; this space has a distinct outline and a characteristic ovoid form. The bone around the cyst is normal. It is possible that this picture might be confused with that of bone sarcoma, but sarcoma can be differentiated from cyst clinically by the fact that it affects the general health, there is enlargement of the regional glands, there is persistent pain, worse at night, and the joint is apt to be involved. Later in the course of the cysts there is apt to be a fracture line. Other conditions from which these cysts must be differentiated are enchondroma, giant cell tumors and fibrous osteitis.—*Audrey G. Morgan.*

HALL, R. D. MCKELLAR. Clay-shoveler's fracture. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 63–75.

In Western Australia, the term "clay-shoveler's fracture" has been applied to a fracture of one or more spinous processes of the lower cervical or upper thoracic vertebrae, occurring in the great majority of cases in relief workers engaged in shoveling clay. It is only since 1933 that this fracture has become a clinical entity and has been given its distinctive name, implying that it is an occupational injury. The history of the accident is the same in practically all cases: The laborer throws up a shovelful of clay; the clay sticks to the shovel, and the worker feels a sudden stab of pain and sometimes hears a crack somewhere between the shoulders, and is unable to continue working. A similar fracture occurs rarely in laborers employed in other occupations, for example, in shoveling other materials, when the shovel is suddenly stopped by a hidden obstruction; and in tree-grubbing, as in one case of Hall's series when the patient was merely pulling on a root. In his series of 13 cases, 11 of the patients were employed in digging drains, that is, shoveling clay; one was a gravel shoveler; and one was a tree grubber. The site of the fracture is most commonly the spinous process of the seventh cervical vertebra, but it ranges in his series from the sixth cervical to the third thoracic vertebra and in 4 of his patients, two adjacent vertebrae were affected.

It seems that there are three possible mechanisms by which this fracture may be explained: (1) direct muscular violence; (2) reflex muscle contraction; (3) whip-like pull transmitted through the supraspinal ligaments.

The patient complains of pain between the shoulders, nearly always to one side of the midline and sometimes beneath the scapula. The pain is worse on forward stretching of the arms or on attempting to pull or lift anything, or in fact, on performing any action which would produce a passive movement of the scapula away from the midline or an active one toward it. Sometimes the pain goes up to the head or down the spine; occasionally it attacks both the head and the spine; and in some instances it proceeds down the arm, which invariably feels weak. Examination reveals tenderness of the spinous process at the site of fracture, and tenderness along the course of the rhomboidei, on one side. Mobility of the affected spinous process can usually be detected. Sometimes crepitus or clicking can be demonstrated either by the examiner or by performance of certain movements

on the part of the patient. Flexion of the head invariably produces pain.

In the majority of cases, the provisional diagnosis has been "muscle strain." Good lateral roentgenograms reveal the fracture without difficulty with the exception of those cases in which the upper thoracic spine is the seat of the fracture, or in cases of the bull-neck type. Stereoscopic anteroposterior views show the fracture clearly in most cases.

In practically all of Hall's cases the diagnosis of "muscle strain" was made and the patients were treated in the main with massage and movement. The treatment indicated is early removal of the detached fragments. Late removal is not so successful, for the reason that the patient, having made no progress under the treatment instituted, loses confidence when informed that he has a fracture which has not united and that the loose fragment will have to be removed by operation. The failure, Hall believes, is more mental than physical.—*R. S. Bromer.*

Cleaves, Edwin N. An unusual shoulder lesion. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 182–184.

Cleaves states that he recently happened upon a case which he believed to be an example of osteochondritis of the apophyses of the acromion processes of the scapulae. This may be a rare condition, or it may be a common one which has not been brought to light, due to its relatively mild nature. The roentgenograms of his patient showed increased density of the apophyses of the acromion processes and they were smaller than normal. The density was irregular and fragmentation could be detected. A review of the literature failed to disclose the report of such a condition.

The commoner sites for osteochondritis were examined roentgenographically and the patient was found to be free from lesions except for those of the scapulae.—*R. S. Bromer.*

Dickson, Frank D., Diveley, Rex L., and Helwig, Ferdinand C. Thyroid tumor of the humerus without demonstrable goiter; report of a case with biological assay of the tumor. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 151–156.

The authors report a rare instance of so-called primary thyroid tumor of the head of the humerus. On gross and histological examination, the growth resembled a benign adenoma of the thyroid gland. Biological assay with extracts of the tumor showed that it contained a substance which would cause metamorphosis in tadpoles, and, when fed to mice, would decrease the toxicity of acetonitrile for these animals; these findings strongly suggested that the tumor contained thyroid hormone.

Amputation failed to effect a cure and, three and one-half years after disarticulation of the arm at the shoulder, a massive growth recurred. Signs and symptoms of a very acute thyrotoxicosis developed, from which the patient died. Histological examination of the tumor at this time showed it to be much more undifferentiated than the original growth. At no time throughout the entire period of observation until shortly before the patient's death was there any evidence of a growth in the thyroid. At this late date, a very slight lobulation of the gland was palpable, although it was not enlarged and was freely movable.

At the time of the first roentgenographic examination a very destructive process was shown involving the upper end of the left humerus and extending down the shaft. Roentgenograms of the lumbar spine, pelvis, femora and thoracic cage showed no evidence of tumor. After operation, shortly before death, the roentgenograms revealed an opaque mass which had eroded the scapula. A generalized distribution of opaque areas was present throughout both lungs.—*R. S. Bromer.*

Lauro, Armando. Studio radiologico dell' omero umano. (Roentgen study of the human humerus.) *Arch. di radiol.*, Jan.–Apr., 1939, *15*, 37–50.

Roentgenograms are given showing the intimate structure of the human humerus. The author shows how the trabeculature of the various parts of the bone is adapted to securing the greatest strength where there are the greatest demands on the bone. The variations for age and sex also show this same law. There is an obvious relationship between the distribution of spongy tissue and the lines of force. There is denser spongy tissue and a larger amount of it in young subjects who are subject to greater effort. But the spongy tissue persists even in old people in the region of the joints where a certain amount of functional effort is still necessary. The types of fracture generally seen are also dependent on bone trabeculature, fractures generally taking place at the boundary between

one trabecular system and another.—*Audrey G. Morgan.*

RUNCO, ANTONIO. Iconografia radiologica di anomalie di sviluppo degli arti—quadri da eccesso. (Roentgen iconography of anomalies of development of the limbs—pictures produced by excess.) *Arch. di radiol.*, May–June, 1939, *15*, 267–283.

The author describes and illustrates with roentgenograms 10 cases of anomalies of the bones of the limbs due to excess formation of bone. These are for the most part accessory fingers and toes, supernumerary ribs and syndactylism of the fingers and toes. In one case there was a supernumerary bone at the elbow that interfered with the movement of the joint and in one scoliosis of the spinal column and anomalies of the vertebrae. The parents were related in only one case.

The author does not make any attempt to discuss the cause of these anomalies but says that this will be taken up in a later article.—*Audrey G. Morgan.*

RUNCO, ANTONIO. Iconografia radiologica di anomalie di sviluppo degli arti—quadri di difetto. (Roentgen iconography of anomalies of development of the limbs—pictures caused by defect.) *Arch. di radiol.*, May–June, 1939, *15*, 284–317.

The author gives detailed descriptions, illustrated by photographs and roentgenograms, of 11 cases of anomalies of the bones of the limbs due to defective bone formation. They consist largely of absence of the whole or parts of the bones of the hands and feet. The patients in the first and second cases were brother and sister. The bones of the hands and feet were incomplete. A paternal aunt had had similar deformities. In one child three years of age the left arm was entirely lacking and there were defects of the bones of the hands evidently caused by amputation by circular bands. A distant relative on the maternal side had a deformity of one leg which was congenital and a maternal aunt was a deaf-mute. In one case there was enlargement of the frontal sinuses and in another abnormal protrusion of the frontal bosses. In one case the right arm consisted only of a stump about 6 cm. long covered with normal skin without any trace of a scar with three fleshy nodules at the end of it. In one case there was scoliosis of the spinal column with anomalies of the vertebrae. In one case the subject was a fetus of the seventh or eighth month. The skull was unusually large in proportion to the face, the right leg was lacking and the left was amputated at the tibiotarsal joint. The bones of the spinal column were completely lacking, the pelvis was represented by two irregular almost ovoid bones and the arms were very short.

The author intends later to publish a study of the cause of such anomalies.—*Audrey G. Morgan.*

GILLESPIE, JAMES B., and SIEGLING, JOHN A. Dysostosis multiplex. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 171–175.

Dysostosis multiplex is a subvariety of chondrodystrophy. Its features are: dwarf stature; the combination of scaphocephalic and chondrodystrophic deformities of the skull; chondrodystrophic changes in other parts of the skeleton, which give rise to shortness of the neck and trunk, protrusion of the abdomen, kyphosis of the spine, and partial ankylosis of the joints; and a non-skeletal abnormality, clouding of the cornea.

Gillespie and Siegling present an additional case to those already reported in which certain observations of the eyes and roentgenographic studies of the skeletal system, they believe, have not been included in previous reports. Both corneas showed a diffuse clouding which was apparently interstitial. It was questionable whether the periosteal and epiphyseal changes observed in the skeletal system were primarily congenital or secondary to vitamin deficiency. They regard them as evidence of florid rickets and possibly of subclinical scurvy, combined with the primary chondrodystrophic disease.

There is some similarity between the syndrome of dysostosis multiplex and Morquio's disease. In the literature it seems not unlikely that certain cases may have been falsely termed Morquio's disease.—*R. S. Bromer.*

HORWITZ, THOMAS, and CANTAROW, ABRAHAM. Polyostotic fibrous dysplasia. *Arch. Int. Med.*, Aug., 1939, *64*, 280–285.

By the term "polyostotic fibrous dysplasia," the authors connote the condition which by some has been called osteodystrophia fibrosa unilateralis or osteitis fibrosa localisata or osteodystrophia fibrosa cystica generalisata or osteitis fibrosa disseminata, etc. They distinguish it from similar changes as found in hyper-

parathyroidism (osteitis fibrosa cystica or Recklinghausen's disease of bone).

The patient was a Polish woman, aged twenty, who was admitted to the hospital because of pains in the regions of the hips and increasing deformities, during the past nine years. Two years previously she had had an osteotomy of the right femur. Diffuse pains had developed, involving even the upper extremity. Roentgenographically, circular radiolucent areas varying in size from that of a pea to that of a walnut were found in the pelvis. Osteoporosis was conspicuous and cortical expansion was seen in the rami. Similar changes were found in the femora, the tibiae and left fibula. There was a cystic lesion in the right os calcis, and the right scaphoid and cuneiform showed diffuse mottlings. Fusiform expansions were noted in the shafts of the right fourth and fifth metatarsals. The serum calcium values varied from 8.4 to 11.2 mg. per 100 cc.; the serum phosphorus, from 2.2 to 5.2; phosphatase, from 6.5 to 11.2 units; the urine was negative for Bence-Jones bodies, and on a low calcium diet the excretions of calcium and phosphorus were 172 to 348 and 884 to 2,720 mg., respectively, per twenty-four hours. The Wassermann and Kahn reactions were negative. The cholesterol content of the plasma was 119 mg. per cent; sugar, 76; urea nitrogen, 10.5. A biopsy was performed on a segment from the left femur; its cortex was extremely thin; the spongiosa was replaced by gritty, whitish fibrous tissue. There was no definite evidence of parathyroid tumor; the thyroid showed adenomatous glandular hypertrophy. During the subsequent ten months the general condition became aggravated both as to the degree of changes and the amount of pain.

The authors emphasize the normal calcium and phosphorus studies and the fact that no parathyroid tumor could be found—regardless of the changes in the bones. They consider the condition as being due to perverted development of the bone-forming mesenchyme—probably on a congenital basis.—*A. A. de Lorimier.*

Nathan, Louis, and Kuhns, John G. Epiphysitis of the spine. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 55–62.

Nathan and Kuhns studied epiphysitis of the spine in 75 patients during the course of the disease and obtained end-result data in 27. Most of the patients visited the hospital for the treatment of faulty posture. The disease was seen most frequently in rapidly growing children. In 14 patients there was a familial history of similar spinal lesions. Laboratory studies upon these patients were essentially negative.

Roentgenographic examination is essential for diagnosis. Irregularity of the upper and lower surfaces of the vertebral bodies was the most constant finding. Decalcification of the vertebrae was observed in only 8 patients. So-called Schmorl's islands were seen in 21. The late change was an anterior wedging of the vertebral body. All gradations of severity of the lesion were observed.

With treatment, deformity was decreased, but was rarely corrected. In 2 cases no deformity developed. In most instances treatment consisted in the application of a plaster jacket with the spine in extension, and corrective exercises. During the acute early stage of the disease, recumbency in a plaster shell with the thoracic spine in extension, as was carried out in 5 cases, seemed to be the most efficient form of treatment. In their adult patients who had received no treatment or inadequate treatment, severe deformity was usually present. This was commonly associated with pain and weakness in the back.—*R. S. Bromer.*

Dietrich, Harry F., Karshner, Rolla G., and Stewart, Steele F. Tetanus and lesions of the spine in childhood. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 43–54.

At the Children's Hospital, Los Angeles, during the past eighteen years the mortality rate of tetanus has dropped from 80 to 8 per cent. Of the surviving patients who have been examined, 69 per cent showed lesions in the thoracic spine. For this report, the cases of 28 patients, ranging from two to eleven years of age, seen in the wards of the Hospital since 1921, were studied. These were divided into two groups, those observed from 1921 to 1932 and those observed from 1933 to 1938. The mortality rate of the first group was 80 per cent, and of the second, 8 per cent.

The lower rate was due to variation in treatment. The authors believe that in the treatment of tetanus in children, small doses of serum are adequate, that no intrathecal injection of serum should be given, that if serum is injected intravenously, it should be accompanied by adrenalin, and that sedatives are life-saving, and may prove of value in preventing vertebral deformities.

Re-examination of 9 out of 13 patients who had tetanus in childhood showed compression of thoracic vertebrae without demonstrable fracture lines. The degree of involvement varied; in the cases showing the least amount, the compression was limited to the anterior portion of the body of the vertebra. When there was more severe involvement, the entire body was compressed from above downward. Most of the affected bodies were wedge-shaped. Where involvement was most severe, the density of the bodies was increased. The intervertebral spaces were unchanged. The upper and lower borders of the affected bodies were smooth and straight, except in the most severe instances, where they were slightly concave in lateral projection. In some cases the compression reduced the height of the body to less than one-half the normal. The dimensions of the affected vertebrae in the frontal and the median planes were normal. There was no erosion of the pedicles or demonstrable enlargement of the spinal canal, nor was there any evidence of any destructive lesions or cold abscess shadow. In severe cases there was a gentle posterior curvature of the spine in the affected region. The involvement centered about the fifth and sixth thoracic segments extending as high as the fourth and as low as the ninth, thus differing in location from kyphosis dorsalis juvenilis in which changes are most severe in the eighth and ninth vertebrae and are almost always limited to the lower half of the thoracic spine.

In differential diagnosis the following conditions which may cause collapse or shortening of the vertebrae must be considered: fracture of the vertebral bodies, tuberculosis of the spine, malignant lesions of the vertebrae, either primary or metastatic, osteomyelitis, coccidiosis, actinomycosis or blastomycosis, lues, lesions following typhoid fever, osteoporosis and metabolic disturbances, hyperfunction of the parathyroid glands, microspondylia and platyspondylia, osteochondritis or epiphysitis, extradural cysts of the spinal cord, fetal chondrodystrophy and osteochondrodystrophy.

Subjectively none of the patients complained of symptoms such as pain or fatigue. Objectively, three observations were made: (1) there was absence both of local tenderness and muscle spasm; (2) motion of the affected segment was slightly restricted; (3) the affected area was marked by flattening rather than by kyphosis. The junction of each end of the flattened area with the normal spine appeared to be slightly angulated.

It is the authors' conception that a vertebral body, like a block of wood, breaks down under repeated blows. One can conceive a convulsion severe enough to fracture a vertebral body, and one can imagine that many minor tetanic convulsions would hammer the mid-thoracic bodies until the whole structure crushed down within itself, giving the picture found by the authors in their patients. As the condition is found to be practically symptomless, treatment has been found to be useless.—*R. S. Bromer.*

BATT, RICHARD C., and HAMPTON, AUBREY O. Spontaneous subcapital hip fractures occurring in tabes dorsalis. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 137–146.

Batt and Hampton studied all cases of hip fractures seen at the Massachusetts General Hospital since 1920 and found 5 cases of spontaneous fracture of the neck of the femur through the site of the epiphyseal line in adults. Three of these patients were known tabetics. Recognition of the fracture in another case led to a diagnosis of latent syphilis. A similar fracture was seen in only one other condition, namely, radiation osteonecrosis.

They recognize four diagnostic criteria: (1) a break through the epiphyseal region between the femoral head and neck; (2) flocculent areas of calcification in the soft tissues surrounding the hip joint; (3) an apparent increased density of the femoral head; and (4) a history of little or no trauma to account for the fracture.

The believe that in view of the pathological changes and the clinical aspects of these cases, one is justified in suspecting tabes when this fracture occurs.—*R. S. Bromer.*

KING, DON; LEEF, EDWARD, and TERWILLIGER, C. K. The importance of accurate roentgenography and interpretation in femoral-neck fractures treated by internal fixation. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 168–170.

The authors' purpose in this paper is to re-emphasize the importance of great care in the making and interpretation of roentgenograms at the time when the nail or bolt is inserted in operations for internal fixation of fractures of the femoral neck. They cite an instance in which the lateral view of the hip joint was obtained after insertion of the nail by flexing the thigh to 90 degrees. In the anteroposterior view the nail

appeared to be placed somewhat low, but seemed to have penetrated the head satisfactorily. Before the patient left the operating room, the leg was placed on a Braun splint, so that the nail could not have been dislodged through trauma if it had been in the head as it appeared to be in the roentgenograms of both projections. Some three hours later, it was noted that the extremity had become shortened and externally rotated. It was obvious that the nail had not penetrated the head at the time when it was inserted.

The nail had evidently passed through the neck, but had come out anterior to the head. As the nail passed inward along the anterior surface of the head, the fragments disengaged, due partly to the rotation of the head. When the thigh was flexed to 90 degrees (for the lateral roentgenogram), the nail rotated, and, although it actually lay on the anterior surface of the head, it had the roentgenographic appearance of being within it.

The illustrations of the article demonstrate the danger of using the "flexed-thigh position" to obtain the lateral view. This method of taking the lateral view is not recommended.—*R. S. Bromer.*

Codeca, Giovanni. Aspetti radiologici della evoluzione della tubercolosi del pube. (Roentgen images in the course of tuberculosis of the pubis.) *Arch. di radiol.*, Jan.–Apr., 1939, *15*, 17–33.

The author gives 22 roentgenograms illustrating different stages in the course of the development of tuberculosis of the pubis. This localization of bone tuberculosis is very rare. The author saw only 10 cases in the examination of 2,000 cases of bone and joint tuberculosis—5 per thousand. In the first stage of the disease there are no clinical signs of its presence; and the roentgen signs are limited to a diffuse decalcification which is also seen in a number of other diseases. This may be called the prodromal period in which the bone changes are as yet microscopic. There are three further stages of the disease, the initial, the progressive and the reparative. The specific tuberculous lesions are not visible until they have reached the size of a pea. Generally this period lasts from two to three months and generally the patients do not come for examination until the disease has reached the progressive stage. In this stage the changes are so characteristic that they can hardly be mistaken for anything else. The bone defects are irregular in form and show marked decalcification. The signs of inflammation reach their greatest intensity in this stage. The decalcification may be so great as to simulate a loss of substance even before there has been any erosion of bone. The roentgenograms show characteristic destructions of bone in this stage. It is during this stage that cold abscesses appear. It may be necessary to use contrast media, such as iodized oil, to demonstrate them and the course of the resultant fistulas.

During the third or reparative stage there is first an arrest of progress of the lesions. It may take several successive roentgenograms to demonstrate this. Then there is a gradual decrease in the inflammatory phenomena and the formation of granulation tissue which fills in the defects in the bone. Finally, the new-formed bone tissue becomes recalcified and sometimes the defects are filled in entirely and the outline is regularized until it is hard to detect the site of the former lesions. In most cases, however, repair is not so perfect and it is hard to determine from the roentgen picture whether healing is complete. A careful study of both the roentgen and clinical pictures is necessary for the demonstration of complete healing.—*Audrey G. Morgan.*

Ulrich, Helmuth. Multiple myeloma. *Arch. Int. Med.*, Nov., 1939, *64*, 994–1016.

A carefully studied case is reported as "multiple myeloma." This diagnosis was developed before death (on the basis of biopsy studies of tumors in the testicle) and substantiated by postmortem studies. Yet the case showed several atypical features: tumors in the testes, absence of pain, absence of definite roentgen evidence, the presence of myeloma cells in the circulating blood and hyperproteinemia without Bence-Jones proteinuria. These features prompted an investigation of others' findings and opinions in these cases. A general review is therefore presented with salient considerations as follows:

Cardinal diagnostic clinical signs (two or three to be expected in any case): (1) multiple tumors of the skeletal trunk in one who is more than thirty-five years; (2) pathological fracture of a rib; (3) Bence-Jones proteinuria; (4) lumbar backache and signs of early paraplegia; (5) unexplained anemia; (6) chronic nephritis with azotemia and low blood pressure.

In the case presented here, only (5) and (6) were conspicuous.

Trauma: Reported in 20 per cent of cases (Geschickter and Copeland); of uncertain association in present case.

Pain: Usually associated—absent in only about 4.6 per cent of cases.

Roentgen Evidence: Multiple skeletal tumors in 96.9 per cent of cases.

Bence-Jones Protein: Reported in about 65 per cent (Geschickter) of cases; especially to be expected where there is marked albuminuria; laboratory evidence may be so marked because of relation of salts to acids in solution and because Bence-Jones protein is not a single substance but a group of similar, but not identical proteins—actual presence of it likely in about 80 per cent of cases (Magnus-Levy).

Hyperproteinemia: Blood plasma protein may reach 23.29 per cent (Williams and Coltrin); if above 9.4 per cent, multiple myeloma should be considered (it is also elevated in other conditions such as kala-azar, lymphogranuloma venereum, leprosy, cirrhosis of liver, etc.); coexistence with Bence-Jones proteinuria has been reported but the finding of one would seem to contradict the finding of the other.

Calcium and Phosphorus: Elevated serum calcium with normal or slightly elevated phosphorus reported and probably due to destruction of the skeleton; low phosphorus and high calcium should prompt consideration of hyperparathyroidism.

Extraosseous Myeloma: One other case report (Porchownik) besides present one mentioned testicles tumors. It has been suggested that these lesions are metastatic but the author is inclined to consider the tumors of the testes, in his patient, as primary. He refers to a case report of a "plasmacytoma" involving a tonsil, some eight years before skeletal involvement.

Nature of Myeloma Cells: They have been considered to belong to the lymphoid group by some, whereas others are equally certain that they are of myeloid origin. Peroxidase reactions have been mixed but negative reactions would seem to be valueless since such should be expected by very young cells. It has been suggested that both plasma cells and myeloma cells have their origin in the reticulo-endothelial stroma.

Relation of Myeloma to Leukemia: Contrary to the dictum: "Myeloma is a tumor, leukemia is not a tumor," there is now much evidence indicating a close relationship between myeloma and leukemia. Plasma cells are being recognized in the circulating blood. Experimental studies have shown transmissibility of myeloid leukemias in mice with developments of localized tumors, in some, and diffuse infiltrations in others.—*A. A. de Lorimier.*

TARR, LEONARD, and FERRIS, HENRY W. Multiple myeloma associated with nodular deposits of amyloid in the muscles and joints and with Bence-Jones proteinuria. *Arch. Int. Med.*, Oct., 1939, *64*, 820–833.

Reference is made to Atkinson's review of 643 cases of multiple myeloma in which amyloid was reported in 40 (a reporting incidence 7 per cent). In some cases amyloid has been described in voluntary musculature and in joints —with clinical pictures closely resembling rheumatoid arthritis.

The authors are reporting, in detail, one case which was studied in March, 1935, and again in January, 1938—a time interval of about three years, and they have appended a notation of a case record wherein the clinical studies seem to indicate the same condition with progressive symptoms over a period of five years.

The first case was a female, aged forty-five, presenting complaints of achings in her neck and back for some years and spells of weakness and fever for some weeks. The essential finding was a consistent 1 to 4 plus reaction for albumin in her urine and the typical fluctuation of Bence-Jones protein. One blood count showed 12,000 white blood cells, with 52 per cent lymphocytes, 41 per cent polymorphonuclears, 4 per cent mononuclears, 2 per cent eosinophils and 1 per cent basophils. Roentgenographic studies of the skull, spine, long bones and chest were essentially negative. A bone marrow puncture and an intravenous Congo red for amyloidosis were considered but the patient refused them. Joint pains became more severe but she returned to work and continued until June, 1937, when edema of the ankles and puffiness of the face were noted. When she returned to the hospital in Jaunary, 1938, she was much emaciated. Joint movements were limited but there were no ankyloses. Her temperature reached 103° F., pulse 140. Small masses were noted in various parts. Biopsy of two of these, located in the muscle bundles, revealed them to be plugs of light-

staining hyaline relatively acellular tissue, with a tendency to form whorls. The urine showed large amounts of Bence-Jone protein, pus cells and granular casts. Roentgenography showed a mottled osteolytic process through the skull, chest and long bones. The patient died four weeks after the second entry. The essential findings at postmortem were the amyloid deposits disseminated through muscle bundles, in and about joints and through various organs. Microscopically, plasma cells were found in these masses as well as in capillaries of the kidney.

The authors emphasize the consistent findings of Bence-Jones protein and the disseminated amyloid tumors in a patient who otherwise appeared to be suffering from "arthritis." They consider the edema to have been based upon hypoproteinuria.—*A. A. de Lorimier.*

Thomason, H. A., and Mayoral, A. Syphilitic osteomyelitis. *J. Bone & Joint Surg.*, Jan., 1940, *22*, 203–206.

A case of syphilitic osteomyelitis is reported in which extensive pathological changes were found in the skull, upper cervical vertebrae, the iliac portions of the innominate bones, in the right femur and in the right clavicle and the ribs, right side. These changes illustrate the fact that gummatous osteomyelitis in adults leads to extensive change in the bone dependent upon bone destruction and new-bone formation, in which destruction generally predominates, and produces irregular areas with mottling. The roentgenographic diagnosis of syphilis was not based on any one typical finding, but on the diversity and widespread distribution of the lesions. The diagnosis was confirmed by biopsy.—*R. S. Bromer.*

MISCELLANEOUS

Günsel, Eberhard. Die Pendelbestrahlung bei wanderndem und bei stehendem Einfallsfeld. (Pendulum irradiation with moving and fixed fields of incidence.) *Strahlentherapie*, 1940, *67*, 286–292.

Efforts have been made constantly to adapt roentgen technique to surgical necessities. This is particularly true of the pendulum method of irradiation which was devised twenty-five years ago but has recently been greatly improved by the development of more suitable apparatus. The tube moves like a pendulum over the area to be irradiated so that the incident rays are distributed successively over a number of partial fields. A sketch shows how a large skin area can be treated in this way with a corresponding decrease of the dose on each unit of skin surface. The narrower the moving field of incidence, the shorter the time the individual field will be subjected to irradiation and the more favorable the relationship of the skin dose to the deep dose. This influence of the breadth of the field of incidence on the intensity of the deep dose is shown by a curve. The intensity of the dose acting on the skin is influenced not only by the breadth of the field of incidence but also by that of the total field irradiated. The broader the surface through which the total dose flows to the deep-seated disease, the less each individual skin unit has to bear. The most favorable conditions are therefore created by the use of as narrow a field of incidence as possible and as great a total field.

It is also to be noted that the size of the pendulum angle not only influences the dose but also determines the distribution of the rays around the axis of the pendulum. The most favorable condition from the point of view of distribution of the dose would be a complete revolution of the tube around its axis, as that would make the dose uniform throughout the field covered by the pendulum movement, but in practice a considerably smaller pendulum angle must be used. It is therefore important to adjust the size of the pendulum angle to the depth of the pathological focus in order to give the latter the maximum deep dose. This decrease in the amount of dosage depending on the size of the pendulum angle can be calculated and also measured technically.

In order to show the difference in action of irradiation through a moving field of incidence, that is with a tube in pendulum movement, and that with a fixed tube a film was embedded in wax and subjected to the two kinds of irradiation. A photograph of the films is given.

This method has been best developed for deep lesions, but it can also be used, though the technique has not been so well worked out, for certain tumors on the surface of the body. It helps to distribute the dosage throughout the tumor without injuring surrounding normal tissue.—*Audrey G. Morgan.*

CARDILLO, FURIO. Considerazioni ed esperienze sulle radiografie eseguite a brevissima distanza. (Theoretical consideration and experience in roentgenography at very short distances.) *Radiol. med.*, July, 1939, *26*, 622–633.

The author discusses the mathematical principles involved in the taking of roentgenograms at very short distances—that is, with the focus at a short distance from the object to be roentgenographed. He shows by his own experience with this method that it is particularly well adapted for the taking of bones, especially when the side of a bone cavity opposite the focus is to be roentgenographed, as the side next the focus practically disappears, thus avoiding the superposition of bone shadows seen in ordinary roentgenography, as in the skull or the thoracic cavity. Illustrative roentgenograms are given.

The author analyzes the indications for this form of roentgenography which is called plesioroentgenography and tries to establish the boundaries of its field of usefulness. The best form of roentgen tube for use in this method is one that makes it possible to reduce the distance from the focus to the object to 2 cm. He also concludes that tubes with a small focus are superior to those with a large focus.—*Audrey G. Morgan.*

GILARDONI, ARTURO. Controllo rapido dei tempi di esposizione radiografiche con schermo fluorescente a lunga luminosità residue. (Rapid control of roentgen times of exposure with a fluorescent screen with long residual luminosity.) *Radiol. med.*, Dec., 1939 *20*. 1131–1132.

This new method utilizes the long residual luminosity of special fluorescent screens. The fluorescent substances used for these screens are generally sulphates of zinc or cadmium, suitably activated. These substances are used for the luminous instruments on airplanes and in many other ways.

In controlling the exposure time the opening through which the rays pass out is covered with a lead plate 1 mm. in thickness with an opening 3 mm. in diameter corresponding to the central ray. A fluorescent screen with long residual luminosity is moved in front of this opening with a suitable rapidity during the roentgen exposure so that a number of luminous points are impressed on the screen corresponding to the number of impulses of radiation emitted. The frequency of the alternating currents is noted and the number of luminous spots and it is easy to determine the time of roentgen exposure.

The controls with this system should be made in semi-darkness to prevent preliminary stimulation of the screen by the light and to see the luminous spots on the screen longer. In practice the time controllable by this method extends to about 0.3 second. For a good stimulation of the screen a short focus-screen distance should be used, about 15 to 20 cm., with charges of about 50 ma., and a tension of 70 kv. The method is illustrated.—*Audrey G. Morgan.*

SUBJECT INDEX TO VOLUME 44

(abs) = abstract (E) = editorial

Abdomen, auxiliary methods and drugs in diagnosis of pathological conditions of (abs), 800
calcification in neuroblastoma in, 175
problems in differential diagnosis between urologic lesions and lesions of (abs), 796
Abdominal aortic aneurysm, ruptured, diagnosis of (abs), 154
Abscess, gas, of pancreas, 485
perinephric, 71
pulmonary, 530
Abscesses, apparently healed lung, bronchographic study of (abs), 152
Accessory stomach in right thorax (abs), 154
Acetabulum, adolescent deformities of (abs), 158
Acromegaly, vertebral column in, 552
Adenomata, pituitary, follow-up study of surgical results in 338 cases (abs), 148
Adolescent deformities of acetabulum (abs), 158
development of sella turcica and frontal sinus based on consecutive roentgenograms, 665
Adrenal glands, cortical and medullary tumors of, modified air injection roentgen technique for demonstrating (abs), 933
main indication for radiation treatment of (abs), 479
Agar jelly in roentgen examination of stomach, 459
Alimentary tract, results of protracted fractional roentgen irradiation of carcinoma of (abs), 315
Alpha rays, biological effect of, in problem of weak radium therapy (abs), 318
deep therapy with (abs), 801
American College of Radiology, new officers, 301
professional bureau of, 294
American Radium Society, 913
report of Research and Standardization Committee of, 909
report of annual meeting, 138
American Registry of X-Ray Technicians, placement bureau of, 300
American Roentgen Ray Society, annual meeting (E), 450, (E), 763
annual meeting, commercial exhibit, 777
annual meeting, committees on local arrangements, 296
annual meeting, golf tournament, 296
annual meeting, ladies program, 297
annual meeting, officers elected, 913
annual meeting, preliminary program, 129
annual meeting, scientific exhibit, 771
Amniotic fluid, aspiration of, by fetus (abs), 644
Anatomy, roentgen, of extrahepatic bile tracts (abs), 643
roentgen, of sulci and vessel channels of skull (abs), 782
Aneurysm, cirsoid venous, roentgen demonstration of (abs), 795
ruptured abdominal aortic, diagnosis of (abs), 154
Aneurysms, spontaneous arteriovenous, of thorax (abs), 151
syphilitic aortic, cor pulmonale due to obstruction of pulmonary artery by (abs), 151
Anomalies of development of limbs, roentgen iconography of (abs), 938
of development of lower limbs, iconography of (abs), 794
of vertebral column, persistence of notochord, 719
Anus, carcinoma of, incidence, pathology and radiation treatment, 265
Aorta, dextroposition of arch of (abs), 784
Arteriosclerotic dysbasia, intermittent, functional radiation therapy of (abs), 160
Articular processes of vertebrae, primary pyogenic osteomyelitis of (abs), 470
Ascaridiasis, roentgen examination in (abs), 787
roentgen picture in (abs), 466
Atelectasis, massive, spontaneous pneumothorax associated with (abs), 152
Auricle, enlarged left, roentgen appearance of, in patients with mitral disease, 834

Barite pneumoconiosis, study of (abs), 464
Basedow's disease; See: Exophthalmic goiter
Besnier-Boeck's disease of lungs, course of, in serial roentgenograms, 564
Bile calculus, occlusion of duodenum by (abs), 788
tracts, extrahepatic, roentgen anatomy of (abs), 643
Biological action of ionizing radiations, some aspects of, 649
Bladder, carcinoma, results of supervoltage roentgen therapy in, 586
inoperable cancer, effect of fractional roentgen irradiation on, 401
Blood, correlation of roentgen and blood examinations in multiple myeloma, 858
stream, rate of removal of thorium dioxide from (abs), 320
vessels, of skull, roentgen anatomy of channels (abs), 782
Body, entire, treatment of polycythemia by irradiation of (abs), 310
section roentgenography, practical applications of, 24
Bone and joint complications in Malta fever (abs), 474
benign giant cell tumor of, five year cure, 884

changes associated with lymphogranuloma venereum (abs), 157
changes in leukemia, 31
circulatory changes in, 90
marrow, effect of roentgen rays on, in vivo and in vitro (abs), 319
marrow of white mouse, effect of single roentgen dose on (abs), 323
metastases from carcinoma of prostate, 732
metastases from primary carcinoma of lung (abs), 469
metastases in genital carcinoma of female (abs), 469
metastases of sarcomata, roentgen study (abs), 469
metastases, squamous cell epithelioma of cervix uteri with, 579
BONES, action of roentgen rays on (abs), 319
of neck, small accessory, 714
BOOK REVIEWS
A Bibliography of the Writings of Harvey Cushing. By the Harvey Cushing Society, 142
Endocrine Gynecology, By E. C. Hamblen, 143
The Electrocardiogram and X-Ray Configuration of the Heart. By Arthur M. Master, 144
La roentgenchimografia cardio-vascolare. By Pietro Perona, 144
A Manual of Roentgen Diagnosis. By Kenneth S. Davis, 144
Radiodiagnostico. Tomo I and II. By Gonzalo Esguerra Gomez, 145
Grundlagen der Röntgendiagnostik und Röntgentherapie. By G. Schulte and F. Kuhlmann, 145
Ergebnisse der physikalisch-diätetischen Therapie. By W. Heupke, J. Kowarschik and J. Kühnau, 145
Radiologie clinique du coeur et des gros vaisseaux. By Ch. Laubry, P. Cottenot, D. Routier and R. Heim de Balsac, 635
Gastrointestinal Dysfunction. By Barton Arthur Rhinehart, 635
The Hospital Care of Neurosurgical Patients. By Wallace B. Hamby, 636
A Topographic Atlas for X-Ray Therapy. By Ira I. Kaplan and Sidney Rubenfeld, 636
Traité d'électro-radiothérapie. L. Delherm and L. Laquerrière, Editors, 636
Das Wesen und der Wert der Tomographie. By W. Deutschmann, 637
The Medical Career, and Other Papers. By Harvey Cushing, 914
Handbook of the Hospital Corps, United States Navy, 1939, 915
Fourth Saranac Laboratory Symposium on Silicosis. Edited by B. E. Kuechle, 916
Anatomy of the Human Lymphatic System. By H. Rouvière. Translated by M. J. Tobias, 916
Peripheral Vascular Diseases: Diagnosis and Treatment. By William S. Collens, and Nathan D. Wilensky, 916
Symposium on the Synapse. By H. S. Gasser, Joseph Erlanger, D. W. Bronk, Rafael Lorente de Nó, and Alexander Forbes, 916
Traumi cranici: chirurgia—neurologia—radiologia. By Mario Lapidari, Ludovico Mucchi, and Virginio Porta, 917
Beiträge zum Verständnis der Leistungsfähigkeit des medizinischen Durchleuchtungsverfahrens. By Helge Christensen, 918
BRAIN, gliomatous tumors of, therapeutic influence by roentgen irradiation (abs), 798
tumors, effect of fractional roentgen irradiation on, 401
BREAST, cancer, pleural metastases from (abs), 784
carcinoma, advanced and recurrent, treatment of, 866
carcinoma, regression of, following artificial menopause, 108
fibrocystic disease of (abs), 153
inoperable cancer, effect of fractional roentgen irradiation on, 401
preoperative irradiation of, 98
BRONCHI, carcinoma, bronchographic examination, 370
major, clinical recognition of tuberculosis of (abs), 924
BRONCHIAL OBSTRUCTION, cause of failure of lung to expand following thoracotomy for empyema, 178
BRONCHIECTASIS, diagnosis by lipiodol bronchograms, 530
BRONCHOGRAMS, lipiodol, value of proper interpretation of, in thoracic surgery, 530
BRONCHOGRAPHY, examination of bronchogenic carcinoma by, 370
study by, of apparently healed lung abscesses (abs), 152
BRONCHOPNEUMONIA, suppurative, without abscess, 345
BULLETIN OF INTER-SOCIETY FOR RADIOLOGY, 132, 294, 454, 630, 768, 909

CALCIFICATION in abdominal neuroblastoma, 175
large intracerebral, probably of traumatic origin (abs), 921
of costal cartilages (abs), 922
of crystalline lens and vitreous (abs), 921
of vaginal sheath of testicle (abs), 788
CALCIFICATIONS, endocardial, study of, by roentgen kymography (abs), 150
mitral valve, roentgen differentiation of rheumatic from non-rheumatic, 704
CALCIFIED joint chondromatosis (abs), 794
lesions, nature of, special reference to those in spleen, 209
CALCINOSIS universalis (abs), 155
CALCIUM bile, diagnosis of (abs), 468

bile, roentgen picture of, and differential diagnostic evaluation (abs), 468
metabolism, abnormalities of (abs), 155
Calculi, cystine urinary, roentgen study, 537
Calculus, large bile, occlusion of duodenum by (abs), 788
unusual case of transparent intrauretero-pelvic, in ureteropyelography (abs), 932
Caldwell Lecture, 1939, 485
Cancer, etiological factors in some forms of, 110
inoperable, effect of fractional roentgen irradiation on several groups of, 401
of breast, pleural metastases from (abs), 784
relation of lymphatic vessels to spread of (abs), 158
Carcinoma, bronchogenic, bronchographic examination, 370
deep infiltrating, treatment of, by means of close irradiation (abs), 311
epidermoid, of skin, study of pathologically verified (abs), 795
genital, of female, osseous metastases in (abs), 469
of anus, incidence, pathology and radiation treatment, 265
of bladder, results of supervoltage roentgen therapy in, 586
of breast, advanced and recurrent, treatment of, 866
of breast, regression of, following artificial menopause, 108
of cervix uteri, advanced, with involvement of efferent urinary passages, fractional roentgen irradiation of (abs), 317
of cervix uteri, results of supervoltage roentgen therapy in, 586
of cervix uteri, significance of radiation reaction in (abs), 641
of cervix uteri treated by roentgen and radium radiation (abs), 799
of esophagus, radium therapy (abs), 479
of lip (abs), 307
of lip, evaluation of neck dissection in (abs), 799
of lip, radiation treatment (abs), 307
of lip, roentgen treatment (abs), 313
of lower lip, results of supervoltage roentgen therapy in, 586
of ovary, results of supervoltage roentgen therapy in, 586
of pancreas, 485
of prostate, bone metastases from, 732
of prostate, results of supervoltage roentgen therapy in, 586
of rectum, results of supervoltage roentgen therapy in, 586
of skin and lip, large protruding, treated by irradiation and surgery, 254
of skin, close roentgen irradiation of (abs), 797
of skin, roentgen treatment (abs), 313
of thyroid, results of supervoltage roentgen therapy in, 586
of tongue, results of supervoltage roentgen therapy in, 586
of tongue, treatment of glandular metastases in (abs), 477
of upper respiratory and food passages, results from protracted fractional roentgen irradiation of (abs), 315
of uterine cervix, individual radium treatment of (abs), 316
of uterus, results of supervoltage roentgen therapy in, 586
of uterus, results of treatment (abs), 318
of vallecula, therapy of (abs), 316
of vocal cords (abs), 478
prepyloric ulcer and (E), 288
primary, of lung, bone metastasis from (abs), 469
primary, of lung, early manifestations (abs), 153
primary, of lung, roentgen study of 206 proved cases, 357
renal cell, diffuse bone metastases from (abs), 156
results from irradiation of, in course of twenty-five years (abs), 475
results of treatment from 1927 to 1931 (abs), 475
squamous cell, of renal pelvis (abs), 155
urethral, radiation therapy (abs), 309
uterine, and ovarian function (abs), 481
Cardiac decompensation, roentgen therapy of thyroid gland in treatment of (abs), 314
Carpal navicular, fractures of, importance of special roentgenography (abs), 471
Case, James T., portrait opposite page 485
Cavities, healing of (abs), 153
Cell division, effect of roentgen rays on (abs), 322
Cerebellum, pneumo-encephalographic appearance of hemangioblastoma of, 1
Chamberlain, W. Edward, honored, 301
Chemical compounds, normally occurring intracellular, rôle played by, in growth and development, 444
Chemotherapy and roentgen therapy of pemphigus (abs), 642
Chicago Roentgen Society, 302
Childhood, tetanus and lesions of spine in (abs), 939
Children, duodenal ulcer in (abs), 785
problem of thymus in (abs), 923
subacute pneumonia in (abs), 924
Cholelithiasis, comparison of roentgenography and duodenal drainage in diagnosis of, 203
Cholesteatoma, roentgen diagnosis of (abs), 782
Chondromatosis, calcified joint (abs), 794
Christian's syndrome (abs), 934
roentgen therapy (abs), 934
Circulatory changes in bone, 90
Clavicle, idiopathic cysts of, in young subjects (abs), 936

CLAY-SHOVELER'S FRACTURE (abs), 936
CLEIDOCRANIAL DYSOSTOSIS, familial (abs), 794
COAL MINERS, anthracite, incidence of pulmonary and extrapulmonary tuberculosis in (abs), 926
COLON, passage of opaque medium into, under normal conditions (abs), 931
COMMISSION ON GRADUATE EDUCATION, summary of report of, 299
CONFERENCE OF EASTERN RADIOLOGISTS, 777
CONGENITAL absence of ramus of mandible (abs), 789
bowing and pseudarthrosis of lower leg associated with von Recklinghausen's neurofibromatosis (abs), 793
dislocation of hip joint, early diagnosis of, 37
dislocation, primary anterior, of hip (abs), 791
goiter, sporadic, causing death of an infant (abs), 785
CONVULSIVE STATES, fractures of spine in, 726
COOLEY'S DISEASE, study of familial character of (abs), 934
COR PULMONALE due to obstruction of pulmonary artery by syphilitic aortic aneurysms (abs), 151
CORACOCLAVICULAR JOINT (abs), 473
COSTAL CARTILAGES, calcification of (abs), 922
CRUCIATE LIGAMENT, anterior, ossification in (abs), 474
CRYSTALLINE LENS, calcification of (abs), 921
CYST, echinococcus, of left lobe of liver, 207
"CYSTIC" disease of lung, 848
CYSTINE urinary calculi, roentgen study of, 537
CYSTS, dermoid, of ovary (E), 905
idiopathic, of clavicle in young subjects (abs), 936
pancreatic, 485
Rathke's (abs), 149

DECOMPENSATION, cardiac, roentgen therapy of thyroid gland in treatment of (abs), 314
DENTAL MOLDS, application of, to radium therapy, 303
DEVELOPMENT of lower limbs, roentgen iconography of anomalies of (abs), 794
DEXTROPOSITION of arch of aorta (abs), 784
DISLOCATION, congenital, of hip joint, early diagnosis, 37
old, functioning false shoulder joint following (abs), 473
primary anterior congenital, of hip (abs), 791
DOSAGE, interstitial radium, expressed in roentgens, 276
DOSE, single roentgen-ray, effect of, on bone marrow of white mouse (abs), 323
Drosophila melanogaster Meig, experiments with rhythmical irradiation of eggs of (abs), 803
DRUG ADDICTS, structural changes in lungs of (abs), 925
DRUGS, effect of, on normal lung outline in roentgenograms (abs), 926
DUODENAL drainage, comparison of, with roentgenography in diagnosis of cholelithiasis, 203
DUODENUM, accessory pancreas of wall of, and its roentgen image (abs), 931
diagnostic errors in ulcerative lesions of, 48
foreign bodies in (abs), 929
function of, in some diseases of stomach (abs), 929
occlusion of, by large bile calculus (abs), 788
ulcer of distal end of first portion of, and extrabulbar duodenal ulcer (abs), 785
ulcer of, in children (abs), 785
DYSOSTOSIS MULTIPLEX (abs), 938
DYSPLASIA, polyostotic fibrous (abs), 938

ECHINOCOCCUS, calcified, of tail of pancreas (abs), 786
cyst of left lobe of liver, 207
cyst with detachment (abs), 926
EDITORIALS
Medical uses of radium, 123
Prepyloric ulcer and carcinoma, 288
Lateral pyelography, 289
Walter Wendell Fray, 1892–1940, 290
On to Boston, 450
The function of the vertebral veins and their rôle in the spread of metastases, 620
William A. Evans, 1876–1940, 623
James Wilson Hunter, Jr., 1878–1940, 626
The annual meeting, 763
Dermoid cysts of the ovary, 905
EFFECT, biological, of alpha rays in problems of weak radium therapy (abs), 318
biological, of ionizing radiations, some aspects of, 649
deleterious, of deep roentgen irradiation on lung structure and function, 235
general and indirect, of roentgen rays and importance in treatment of malignant tumors (abs), 801
general, of irradiation on organism (abs), 797
of experimentally formed tumors on musculoskeletal system of rat (abs), 320
of fractional roentgen irradiation on several groups of inoperable tumors, 401
of radiotherapy as recorded by serial color photography, 250
of roentgen irradiation on lymphatic transport of India ink, 756
of roentgen radiation on striated musculature when tolerance threshold of skin is exceeded, can it be demonstrated? (abs), 322
of roentgen rays on bone marrow in vivo and in in vitro (abs), 319
of roentgen rays on bones (abs), 319
of roentgen rays on cell division (abs), 322
of roentgen rays on Galliera sarcoma in vivo and in vitro (abs), 321
of short waves on renal function (abs), 643
of single roentgen dose on bone marrow of white mouse (abs), 323

of tangency and of principle of psycho-physical relativity (abs), 644
Elbow joint, detachment of medial epicondyle of humerus with displacement into (abs), 157
Emphysema, obstructive, roentgen evidence of, 325, 912
spontaneous interstitial, of lungs (abs), 152
Empyema, acute postpneumonic, causes of failure of lung expansion following thoracotomy for, 178
Epicondyle, medial, detachment of, of humerus, with displacement into elbow joint (abs), 157
Epihyal bone, 714
Epiphyseal coxa anteverta, internal-rotation-brace treatment of (abs), 792
Epiphysitis of os calcis (abs), 473
of spine (abs), 939
Epithelioma of skin, guiding principles for use of close irradiation in (abs), 477
squamous cell, of cervix with bone metastasis, 579
Epitheliomata of gums, radium therapy of (abs), 476
Epulis (abs), 150
Esophagus, carcinoma, radium therapy (abs), 479
pleural manifestations of perforation of (abs), 784
Etiological factors in some forms of cancer, 110
Evans, William A., 1876–1940, obituary (E), 623
portrait, 623
Examinations, selective service, 910
selective service, cost schedules for, 912
Exophthalmic goiter, how should it be treated at present time? (abs), 480
Exudates, basal, of subphrenic origin, 350
Eye, radium treatment of rodent ulcer near, 737
Eyeball, roentgenographic examination of anterior portion of, for foreign body, 778

Face, stratigraphy of sinuses of (abs), 783
Failla, G., portrait opposite page 649
Fatigue manifestations of scaphoid bone from chronic trauma (abs), 474
Fees, collection of, 909
Femur, fractures of neck of, importance of accurate roentgenography and interpretation in, treated by internal fixation (abs), 940
fractures of neck of, new device for facilitating taking of roentgenograms when performing extra-articular method of internal fixation in (abs), 483
nature of circumscribed areas of rarefaction in neck of, in Perthes' disease (abs), 472
pathology of ununited fractures of neck of (abs), 791
Fetus, aspiration of amniotic fluid by (abs), 644
Fibrocystic disease of breast (abs), 153
Fibrosarcoma, soft tissue, pathological features of (abs), 800
Filters, changeable, roentgen treatment of leukemia with (abs), 307
Fistula, ileovesical (abs), 931
Flajani-Basedow's disease; See: Exophthalmic goiter
Fluorescent screen with long residual luminosity, rapid control of roentgen times of exposure with (abs), 944
Fluorine poisoning, chronic, from roentgenological standpoint (abs), 935
Foreign bodies in duodenum (abs), 929
intraocular, localization of, with contact lens, 558
roentgen search for and localization, modern methods (abs), 804
roentgenographic examination of anterior portion of eyeball for, 778
Fracture, avulsion, of mastoid process (abs), 471
clay-shoveler's (abs), 936
Fractures, femoral-neck, importance of accurate roentgenography and interpretation in, treated by internal fixation (abs), 940
of carpal navicular, importance of special roentgenography (abs), 471
of femoral neck, new device for facilitating taking of roentgenograms when performing extra-articular method of internal fixation in (abs), 483
of femoral neck, simplified directional guide for hip nailing (abs), 472
of pelvis (abs), 158
of spine after metrazol convulsive therapy and other convulsive states, 726
of vault of skull, roentgen examination of (abs), 782
spontaneous subcapital of hip, occurring in tabes dorsalis (abs), 940
ununited, of neck of femur, pathology (abs), 791
Fragilitas ossium (abs), 155
Fray, Walter Wendell, 1892–1940, obituary (E), 290
portrait, 290
Frontal puncture for ventriculography (abs), 149

Gallbladder, diagnosis of "calcium bile" (abs), 468
roentgen picture of calcium bile and differential diagnostic evaluation (abs), 468
Galliera sarcoma, effect of roentgen rays on, in vivo and in vitro (abs), 321
irradiated in vivo and in vitro, experimental research on (abs), 802
Gallstone, intestinal obstruction due to, 634
large irregular, intestinal obstruction at terminal ileum caused by, 69
Gallstones, intestinal obstruction due to (abs), 154
Gamma radiation from radium, measurement of, in roentgens by free air ionization chamber, 428
radiation, measurement of, in roentgens, 889

Gastritis, hypertrophic, malignant course of (abs), 929
Gaucher's disease, chronic (abs), 935
Generator, compact, supervoltage, roentgen-ray, using pressure-insulated electrostatic high voltage source, 610
Genital carcinoma of female, osseous metastases of (abs), 469
Glandular metastases in carcinoma of tongue, treatment of (abs), 477
Gliomas, therapeutic influence of, by roentgen irradiation (abs), 798
Goiter, sporadic congenital, causing death of infant (abs), 785
Grenz rays, studies of sensitizing action of tar preparations on skin irradiated with (abs), 803
Growth, rôle played by normally occurring chemical compounds in growth and development, 444
Gums, epitheliomata of, radium therapy (abs), 476

Hand-Schüller-Christian's disease; See: Christian's syndrome
Heart, changes in size and shape of shadow of, in chronic pulmonary tuberculosis (abs), 927
roentgen kymographic evaluation of size and function of, 805
roentgen kymography of, clinical applications and limitations (abs), 466
valve areas, movements of roentgen-opaque deposits in (abs), 150
Hemangioblastoma of cerebellum, pneumo-encephalographic appearance of, 1
Hemangioma of joints (abs), 157
Hematoma, subdural, diagnosis and treatment (abs), 148
Hemorrhages, climacteric, new roentgen method in treatment of, with sparing of ovaries (abs), 308
Hepatosplenography with thorium dioxide, should it be completely abandoned? (abs), 467
Hip fractures, spontaneous subcapital, occurring in tabes dorsalis (abs), 940
joint, congenital dislocation, early diagnosis of, 37
joint of infant in first twelve months of life, roentgen study, 37
primary anterior congenital dislocation of (abs), 791
simplified directional guide for nailing of (abs), 472
Hospitals and radiologists, principles of relationship between, 423
Humerus, detachment of medial epicondyle of, with displacement into elbow joint (abs), 157
human, roentgen study of (abs), 937
thyroid tumor of, without demonstrable goiter (abs), 937
Hunter, James Wilson, Jr., 1878–1940, obituary (E), 626
portrait, 626
Hydromicrocephaly, syndrome of (abs), 921
Hyperostoses in relation with the meningiomas (abs), 149
Hyperthyreosis, results obtained from roentgen treatment of (abs), 159
Hypophysial duct, tumor of (abs), 149
Hypophysis, main indication for radiation treatment of (abs), 479

Iconography, roentgen, of anomalies of development of limbs (abs), 938
Ileitis, hyperplastic ulcerous regional (abs), 930
Ileovesical fistula (abs), 931
Ileum, terminal, intestinal obstruction at, caused by large irregular gallstone, 69
India ink, effect of roentgen irradiation on lymphatic transport of, 756
Indiana Roentgen Society, 302
Induration, plastic, of penis, radium therapy of (abs), 640
Infant, roentgen study of hip joint of, in first twelve months of life, 37
sporadic congenital goiter causing death of (abs), 785
Inflammation of middle lobe of lung, roentgen and clinical characteristics, 464
Inflammatory processes, acute, value and limitations of radium and roentgen treatment in (abs), 310
conditions, roentgen therapy for, 594
Institute of Radiology, 913
Intestinal obstruction at terminal ileum caused by large irregular gallstone, 69
obstruction due to gallstone, 634
obstruction due to gallstones (abs), 154
obstruction, treatment of, and procedure for identifying the lesion (abs), 154
Intestine, human small, intubation of (abs), 154
small, malignant tumors of (abs), 786
Intracellular chemical compounds, normally occurring, rôle played by, in growth and development, 444
Intracerebral calcification, large, probably of traumatic origin (abs), 921
Intraspinal causes of low back and sciatic pain (abs), 790
Invagination, roentgen images of gastro-gastroduodenal and duodeno-duodenal (abs), 786
Ionization chamber, free air, measurement in roentgens of gamma radiation from radium by, 428
Ionizing radiations, some aspects of biological action of, 649
Irradiation, close, guiding principles for use of, in epithelioma of skin (abs), 477
close, new results in malignant melanoma with (abs), 311

close, treatment of deep infiltrating carcinoma by (abs), 311
general effects of, on organism (abs), 797
of entire body in treatment of polycythemia (abs), 310
pendulum, with moving and fixed fields of incidence (abs), 943
preoperative, of breast, 98
results from, in carcinoma in course of twenty-five years (abs), 475
rhythmical, of eggs of *Drosophila melanogaster* Meig, experiments with (abs), 803
to produce sterilization (abs), 481
treatment of primary skeletal sarcoma by, 83
Janeway Lecture, 1939, 649
medal, presentation of, 664
Jejunum, stenotic tuberculosis of (abs), 930
Joint chondromatosis, calcified (abs), 794
Joints, hemangioma of (abs), 157
xanthomatous tumors of (abs), 790
Journal of National Cancer Institute, announcement of publication of, 301

Kidneys, acute suppuration, pulmonary complications of, 161
can intravenous urography be considered a test of function of? (abs), 932
effect of short waves on function of (abs), 643
late results of severe injury to (abs), 932
squamous cell carcinoma of pelvis of (abs), 155
study of motion of, in health and disease, 71
Kienböck's disease of lunate (abs), 472
Kymography as aid in differential diagnosis of mediastinal tumors (abs), 928
roentgen, evaluation of size and function of heart by, 805
roentgen, of heart, clinical applications and limitations (abs), 466
roentgen, study of endocardial calcifications by (abs), 150

Laminagraphy, practical applications of, 24
Larynx, body section roentgenography (planigraphy) of, 519
Leiomyosarcoma of fundus of stomach with perforation, 716
Leishmaniosis of skin treated with roentgen rays (abs), 476
Lens, contact, localization of intraocular foreign bodies with, 558
Leprosy, conquest of, 457
roentgenological observations in, 386
Leukemia, bone changes in, 31
roentgen treatment with changeable filters (abs), 307
Limbs, lower, roentgen iconography of anomalies of development of (abs), 794
roentgen iconography of anomalies of development of (abs), 938
Lip, carcinoma (abs), 307
carcinoma, evaluation of neck dissection in (abs), 799
carcinoma, radiation treatment (abs), 307
carcinoma, roentgen treatment (abs), 313
large protruding carcinoma of, treated by irradiation and surgery, 254
lower, carcinoma, results of supervoltage roentgen therapy in, 586
Lipiodol bronchograms, value of proper interpretation of, in thoracic surgery, 530
Lithiasis, pancreatic, 485
Liver, echinococcus cyst of left lobe of, 207
roentgen and anatomo-histological examination of parasites of (abs), 787
Localization of intraocular foreign bodies with contact lens, 558
of projectiles, modern roentgen methods (abs), 804
Lunate, Kienböck's disease of (abs), 472
Lung abscess and pseudo-abscess, 530
origin of tumors occurring in apex of, 838
Lungs, abnormally wide respiratory movement of lower structures of, 325, 912
abscesses, bronchographic study of apparently healed (abs), 152
basal exudates of subphrenic origin, 350
causes of failure of expansion of, following thoracotomy for acute postpneumonic empyema, 178
changes in roentgen image of outline of, from pharmacodynamic action (abs), 926
complications in, of acute renal and perirenal suppuration, 161
course of Besnier-Boeck's disease of, in serial roentgenograms, 564
"cystic" disease of, 848
deleterious effects of deep roentgen irradiation on structure and function of, 235
healing of cavities (abs), 153
inflammation of middle lobe of, roentgen and clinical characteristics (abs), 464
non-putrid suppuration of, roentgen aspects, 345
of drug addicts, structural changes in (abs), 925
primary carcinoma, bone metastasis from (abs), 469
primary carcinoma, early manifestations (abs), 153
primary carcinoma, roentgen study of 206 proved cases, 357
roentgen study of development of cavities of (abs), 783
spontaneous interstitial emphysema of (abs), 152
unusual course of metastases to, of sarcoma (abs), 465
Lymph nodes, retroperitoneal, their importance in cases of malignant tumors (abs), 159
Lymphadenopathy, giant follicular, radiation treatment of, 875

LYMPHATIC transport of India ink, effect of roentgen irradiation on, 756
vessels, relation of, to spread of cancer (abs), 158
LYMPHOGRANULOMA, radiotherapy of (abs), 643
venereum, osseous changes associated with (abs), 157

MALTA FEVER, bone and joint complications in (abs), 474
MANDIBLE, congenital absence of ramus of (abs), 789
MASTOID process, avulsion fracture of (abs), 471
MEASUREMENT in roentgens of gamma radiation from radium by free air ionization chamber, 428
of gamma radiation in roentgens, 889
MEDIASTINITIS, acute, roentgenological, pathological and clinical features and principles of operative treatment, 684
MEDIASTINUM, tumors of, kymography as aid in differential diagnosis (abs), 928
MEDICAL uses of radium (E), 123
MEDICINE and the press, 768
MEDITERRANEAN FEVER, study of familial character of (abs), 934
MELANOMA, malignant, new results with close irradiation of (abs), 311
MENINGIOMAS, hyperostoses in relation with (abs), 149
MENOPAUSE, artificial, regression of carcinoma of breast following, 108
new roentgen method used in hemorrhages of, with sparing of ovaries (abs), 308
METABOLISM, calcium, abnormalities of (abs), 155
METASTASES, bone, from carcinoma of prostate, 732
bone, from primary carcinoma of lung (abs), 469
bone, of sarcomata, roentgen study (abs), 469
bone, squamous cell epithelioma of cervix uteri with, 579
function of vertebral veins and their rôle in spread of (E), 620
glandular, in carcinoma of tongue, treatment of (abs), 477
in genital carcinoma of female (abs), 469
lung, of sarcoma, unusual course of (abs), 465
pleural, from cancer of breast (abs), 784
to sternum and second rib left from teratoma of right parotid gland, 887
METRAZOL convulsive therapy, fractures of spine after, 726
MINNESOTA RADIOLOGICAL SOCIETY, 141
MITRAL disease, roentgen appearance of enlarged left auricle in patients with, 834
valve calcifications, roentgen differentiation of rheumatic from non-rheumatic, 704
MUSCLE, striated, influence of roentgen radiation on, when tolerance threshold of skin is exceeded (abs), 322
MUSCULOSKELETAL system of rat, effect of experimentally formed tumors on (abs), 320
MYELOMA, multiple (abs), 796; (abs), 941
multiple, associated with nodular deposits of amyloid in muscles and joints and with Bence-Jones proteinuria (abs), 942
multiple, correlation of roentgen and blood examinations in, 858
MYOSITIS OSSIFICANS, progressive (abs), 794

NECK dissection, evaluation of, in carcinoma of lip (abs), 799
recent advances in roentgen examination of, 519
small accessory bones of, 714
NEPHROLITHIASIS occurring in recumbency (abs), 788
NERVOUS SYSTEMS, central and peripheral, radiosensitiveness of skin as dependent on (abs), 322
NEUROBLASTOMA, abdominal, calcification in, 175
NEUROFIBROMATOSIS, congenital bowing and pseudarthrosis of lower leg associated with (abs), 793
NEUTRONS in therapy (abs), 801
NEVI, vascular, radium treatment, 747
NEW YORK Academy of Medicine, 1940 graduate fortnight of, 299
Roentgen Society, 458
NOTOCHORD, persistence of, 719
NUCLEAR PHYSICS, action of (abs), 801
applied, conference on, 297

Obelia geniculata, use of, in study of rôle played by intracellular chemical compounds in growth and development, 444
OBSTETRICAL diagnosis, roentgen ray in, 568
OHIO RADIOLOGICAL SOCIETY, 302
ONION SKIN, use of, for radiobiological research (abs), 803
ORGANISM, general effects of irradiation on (abs), 797
OS CALCIS, epiphysitis of (abs), 473
OSSIFICATION centers, rate of appearance of, from birth to age of five years (abs), 789
in anterior cruciate ligament (abs), 474
OSTEITIS FIBROSA DISSEMINATA (abs), 156
OSTEOARTHROPATHIES, hypertrophying pneumonia (abs), 793
OSTEOCHONDROMA, unusual location of (abs), 789
OSTEOMALACIA, senile (abs), 156
OSTEOMAS, cranial, from roentgenologic viewpoint, 188
OSTEOMYELITIS, hematogenous pelvic, management of (abs), 793
primary pyogenic, of articular processes of vertebrae (abs), 470
syphilitic (abs), 943
OSTEOPETROSIS, 197
OVARIAN function, and uterine carcinoma (abs), 481
OVARIES, new roentgen method used in climacteric hemorrhages, with sparing of (abs), 308
OVARY, carcinoma, results of supervoltage roentgen therapy in, 586
dermoid cysts of (E), 905

Pachypleuritis, paradoxical roentgen image in pneumothorax a result of, 230
Pacific Roentgen Society, 302
Pain, low back and sciatic, intraspinal causes of (abs), 790
Pancreas, accessory, of wall of duodenum and its roentgen image (abs), 931
calcified echinococcus of tail of (abs), 786
carcinoma of, 485
cysts of, 485
gas abscess of, 485
radiation therapy of disease of, 485
roentgenology of disease of, 485
stones in, 485
Pancreatitis, acute and chronic, 485
Parasites of liver and spleen, roentgen and anatomo-histological examination of (abs), 787
Paralysis, progressive, roentgen treatment of (abs), 641
Parathyroid adenoma (abs), 156
Parathyroidism, 113
Parotid gland, benign vascular tumors of region of, treatment with radium moulage (abs), 314
teratoma of, with metastasis to sternum and second rib left, 887
Pelvimeter, roentgen, description of, 9
Pelvimetry, roentgen, discussion of, 9
Pelvis, fractures of (abs), 158
hematogenous osteomyelitis of, management of (abs), 793
renal, squamous cell carcinoma of (abs), 155
Pemphigus, roentgen therapy and chemotherapy of (abs), 642
Penis, plastic induration of, radiation treatment (abs), 483
radium therapy of plastic induration of (abs), 640
Pennsylvania Radiological Society, 141
Pentastoma in liver and spleen, anatomical and roentgen picture (abs), 787
Peptic ulcer, perforated, spontaneous pneumoperitoneum in, 853
Perforation of esophagus, pleural manifestations of (abs), 784
Perthes' disease, nature of circumscribed areas of rarefaction in neck of femur in (abs), 472
Pharmacodynamic action, changes in roentgen image of lung outline from (abs), 926
Photography, serial color, effects of radiotherapy as recorded by, 250
Physical characteristics of supervoltage roentgen rays, 615
Pittsburgh Roentgen Society, 302
Pituitary adenomata, follow-up study of surgical results in 338 cases (abs), 148
Planigraphy of larynx, 519
simple method of adopting conventional roentgenologic equipment to, 638
Plastic induration of penis, radiation treatment (abs), 483
of penis, radium therapy of (abs), 640
Plesioroentgenography, recent contribution to (abs), 483
Pleura, metastases to, from cancer of breast (abs), 784
Pleural manifestations of perforation of esophagus (abs), 784
Pneumoconiosis, barite, study of (abs), 464
Pneumo-encephalographic appearance of hemangioblastoma of cerebellum, 1
Pneumonia, atypical roentgen aspects, 333
subacute, in children (abs), 924
Pneumoperitoneum, spontaneous, in perforated peptic ulcer, 853
Pneumothorax, paradoxical roentgen image in, 230
spontaneous, associated with massive atelectasis (abs), 152
Polycythemia, roentgen treatment of (abs), 308
treatment of, by irradiation of entire body (abs), 310
Polyostotic fibrous dysplasia (abs), 938
case with unilateral involvement, 17
Pregnancy, diagnosis of, 568
Prepyloric ulcer and carcinoma (E), 288
Projectiles, roentgen search for and localization, modern methods (abs), 804
Prostate, carcinoma, bone metastases from, 732
carcinoma, results of supervoltage roentgen therapy in, 586
Protrusio acetabuli, investigation into nature of (abs), 158
Pseudofracture of tibia (abs), 470
Pubis, tuberculosis, roentgen pictures during course of (abs), 941
Pulmonary artery, cor pulmonale due to obstruction of, by syphilitic aortic aneurysms (abs), 151
Pyelography, lateral (E), 289
respiration, 71

Quimby, Edith H., honored, 140

Radiation, penetrating, physical differences between types of, 270
reaction, significance of, in carcinoma of cervix uteri (abs), 641
therapy, functional, of intermittent arteriosclerotic dysbasia (abs), 160
treatment of hypophysis, thyroid and suprarenals, main indication for treatment of (abs), 479
Radiations, ionizing, some aspects of biological action of, 649
200 kv. and 1,000 kv., comparison of skin reactions produced by, 601
Radiobiological experiments, use of onion skin for (abs), 803
Radiological Conference, Midsummer, in Rocky Mountains, 141
practice, present status of, 132

Society of New Jersey, 302
Society of North America, 141
RADIOLOGISTS and hospitals, principles of relationship between, 423
RADIOLOGY, debt of, to Thomsons and Thompsons, physicists and engineers, 409
graduate training in, 301
responsibility of, in diagnosis and treatment of thymic hyperplasia (abs), 922
RADIOTHERAPY, effects of, as recorded by serial color photography, 250
of lymphogranuloma (abs), 643
RADIUM bomb, design of a four gram, 117
control instruments, new, 457
dosage, interstitial, expressed in roentgens, 276
measurement in roentgens of gamma radiation from, by free air ionization chamber, 428
medical uses of (E), 123
moulage, treatment with, of benign vascular tumors of parotid region (abs), 314
therapy, application of dental molds to, 303
therapy of plastic induration of penis (abs), 640
therapy, value and limitations in acute inflammatory processes (abs), 310
therapy, weak, biological effect of alpha rays in problem of (abs), 318
treatment of rodent ulcer near eye, 737
treatment of vascular nevi, 747
RAMUS of mandible, congenital absence of (abs), 789
RATHKE'S cysts (abs), 149
RECTUM, carcinoma, results of supervoltage roentgen therapy in, 586
RECUMBENCY, nephrolithiasis occurring in (abs), 788
REMOGRAPHY (abs), 484
generator for flashes of roentgen light 1/1000 of a second in length for (abs), 484
RESEARCH and Standardization Committee of American Radium Society, report of, 909
RESPIRATION pyelography, 71
RESPIRATORY movement, abnormally wide, of lower lung structures, 325, 912
tract infection, epidemic of acute, roentgen aspects, 333
tract, upper, results of protracted fractional roentgen irradiation of carcinoma of (abs), 315
RHEUMATIC, roentgen differentiation from nonrheumatic mitral valve calcifications, 704
RHINOLITH, case of (abs), 922
RIB, second left, metastasis to, from teratoma of right parotid gland, 887
RICKETS, renal (abs), 155
RODENT ULCER near eye, radium treatment, 737
ROENTGEN anatomy of sulci and vessel channels of skull (abs), 782
anatomy of extrahepatic bile tracts (abs), 643
evidence of tuberculosis and cutaneous sensitivity to tuberculin, sequence of (abs), 784
examination, correlation of, with examination of blood in multiple myeloma, 858
examination of stomach, agar jelly in, 459
iconography of anomalies of development of limbs (abs), 938
iconography of anomalies of development of lower limbs (abs), 794
image, paradoxical, in pneumothorax, result of pachypleuritis, 230
irradiation, close, of skin carcinoma (abs), 797
irradiation, deep, deleterious effects of, on lung structure and function, 235
irradiation, effect of, on lymphatic transport of India ink, 756
irradiation, fractional, effect of, on several groups of inoperable tumors, 401
irradiation, fractional, of advanced carcinoma of cervix with involvement of urinary passage (abs), 317
irradiation, protracted fractional, results of, in carcinoma of upper respiratory and food passages (abs), 315
method, new, in treatment of climacteric hemorrhages with sparing of ovaries (abs), 308
-opaque deposits in heart valve areas, movements of (abs), 150
radiation, is it possible to demonstrate an influence of, on striated musculature when tolerance threshold has been exceeded? (abs), 322
-ray dose, single, effect of, on bone marrow of white mouse (abs), 323
-ray generator, compact, supervoltage, using pressure-insulated electrostatic high voltage source, 610
rays, action of, on bones (abs), 319
rays, combined action of, and sulfanilamide on *Staphylococcus aureus*, 115
rays, effect of, on bone marrow in vivo and in vitro (abs), 319
rays, effect of, on cell division (abs), 322
rays, effect of, on Galliera sarcoma in vivo and in vitro (abs), 321
rays, general and indirect effects of, and their importance in treatment of malignant tumors (abs), 801
rays in obstetrical diagnosis, 568
rays, supervoltage, physical characteristics of, 615
stimulation, study of (abs), 802
therapy and chemotherapy of pemphigus (abs), 642
therapy for inflammatory conditions, 594
therapy of hyperthyreosis, results obtained from (abs), 159
therapy of progressive paralysis (abs), 641
therapy of thyroid gland in treatment of cardiac decompensation (abs), 314
therapy, supervoltage, late results in, 586
therapy, value and limitations in acute inflammatory processes (abs), 310
times of exposure, rapid control of, with fluores-

cent screen with long residual luminosity (abs), 944
Roentgens, interstitial radium dosage expressed in, 276
measurement in, of gamma radiation from radium by free air ionization chamber, 428
measurement of gamma radiation in, 889
Roentgenograms, consecutive, adolescent development of sella turcica and frontal sinus based on, 665
new device to facilitate taking of, when performing extra-articular method of internal fixation in fractures of femoral neck (abs), 483
serial, course of Besnier-Boeck's disease of lungs in, 564
Roentgenography at very short distances, theoretical consideration and experience in (abs) 944
body section, of larynx, 519
body section, practical applications of, 24
body section, simple method of adopting conventional roentgenologic equipment to, 638
comparison of, with duodenal drainage in diagnosis of cholelithiasis, 203
importance of accurate, and interpretation in femoral-neck fractures treated by internal fixation (abs), 940
of sinuses, use of thorium dioxide in, 680
special, importance of, in fractures of carpal navicular (abs), 471
Roentgenologic aspects of epidemic of acute respiratory tract infection, 333
differentiation of rheumatic from non-rheumatic mitral valve calcifications, 704
equipment, conventional, simple method of adopting, to body section roentgenography, 638
Roentgenology of pancreatic disease, 485
specialization within, 645

Sarcoma, bone metastases of, roentgen study (abs), 469
experimental production of, by thorotrast (abs), 320
Galliera, effect of roentgen rays on, in vivo and in vitro (abs), 321
Galliera, irradiated in vivo and in vitro, experimental research on (abs), 802
of vagina, therapy of (abs), 482
polymorphous cell, radiation treatment of, 875
primary skeletal, treatment of, by irradiation, 83
unusual course of lung metastases of (abs), 465
Scaphoid bone, fatigue manifestations of, from chronic trauma (abs), 474
Scapula, osteochondroma on costal surface of (abs), 789
Sclerosis, multiple, roentgen therapy of (abs), 312
Sella turcica, adolescent development of, based on consecutive roentgenograms, 665
Seriography, generator for flashes of roentgen light 1/1000 of second in length for (abs), 484
Short waves, effect of, on renal function (abs), 643
Shoulder joint, functioning false, following old dislocation (abs), 473
unusual lesion of (abs), 937
Silicosis, prognosis in, 709
Sinus, frontal, adolescent development of, based on consecutive roentgenograms, 665
Sinuses of face, stratigraphy of (abs), 783
use of thorium dioxide in roentgenography of, 680
Skeleton, primary sarcoma of, treatment by irradiation, 83
Skin, carcinoma, close roentgen irradiation of (abs), 797
carcinoma, roentgen treatment (abs), 313
epidermoid carcinoma of, study of pathologically verified (abs), 795
epithelioma, guiding principles for use of close irradiation in (abs), 477
influence of roentgen radiation on striated musculature when threshold tolerance of, has been exceeded (abs), 322
large protruding carcinomas of, treated by irradiation and surgery, 254
leishmaniosis of, treated with roentgen rays (abs), 476
radiosensitiveness of, as dependent on central and peripheral nervous systems (abs), 322
reactions, comparison of, produced by 200 kv. and 1,000 kv. radiations, 601
studies of sensitizing action of tar preparations on, irradiated with ultraviolet and grenz rays (abs), 803
tuberculosis and sensitivity of, to tuberculin, sequence of roentgen evidence of (abs), 784
Skull, large intracerebral calcification probably of traumatic origin (abs), 921
osteomas of, from roentgenologic viewpoint, 188
roentgen anatomy of sulci and vessel channels of (abs), 782
roentgen examination in fractures of vault of (abs), 782
Soft tissue fibrosarcoma, pathological features of (abs), 800
Sosman, Merrill C., portrait opposite page 645
South Carolina X-Ray Society, 141
Specialization within roentgenology, 645
Spine, epiphysitis of (abs), 939
fractures of, after metrazol convulsive therapy and other convulsive states, 726
in acromegaly, 552
persistence of notochord, 719
tetanus and lesions of, in childhood (abs), 939
Spleen, nature of calcified lesions in, 209
roentgen and anatomo-histological examination of parasites of (abs), 787
Spondylolisthesis, etiology of (abs), 470

Spontaneous arteriovenous aneurysms of thorax (abs), 151
interstitial emphysema of lungs (abs), 152
pneumothorax associated with massive atelectasis (abs), 152
Staphylococcus aureus, combined action of roentgen rays and sulfanilamide on, 115
Sterilization by irradiation (abs), 481
Sternum, bifurcated and abnormally long xiphoid process of (abs), 465
metastasis to, from teratoma of right parotid gland, 887
Stomach, accessory, in right thorax (abs), 154
agar jelly in roentgen examination of, 459
diagnostic errors in ulcerative lesions of, 48
function of duodenum in some diseases of (abs), 929
inoperable cancer, effect of fractional roentgen irradiation on, 401
leiomyosarcoma of fundus of, with perforation, 716
tuberculosis of, roentgen study, 59
ulcer of greater curvature of, roentgen contribution to study of (abs), 928
Stratigraphy of sinuses of face (abs), 783
Subdural hematoma, diagnosis and treatment (abs), 148
Sulci of skull, roentgen anatomy of (abs), 782
Sulfanilamide, combined action of, and roentgen rays on *Staphylococcus aureus*, 115
Supervoltage roentgen-ray generator using pressure-insulated electrostatic high voltage source, 610
roentgen rays, physical characteristics of, 615
roentgen therapy, late results in, 586
Suppuration, acute renal and perirenal, pulmonary complications of, 161
non-putrid pulmonary, roentgen aspects, 345
Supraspinatus tendon, lesions of, and associated structures (abs), 157
Symmers' disease, radiation treatment of, 875
Synovioma, roentgen recognition of, 170
Syphilitic aortic aneurysms, cor pulmonale due to obstruction of pulmonary artery by (abs), 151
osteomyelitis (abs), 943

Tabes dorsalis, spontaneous subcapital hip fractures occurring in (abs), 940
Tangency, effect of, and of principle of psychophysical relativity (abs), 644
Tar preparations, studies of sensitizing action of, on skin irradiated with ultraviolet and grenz rays (abs), 803
Teratoma of right parotid gland with metastasis to sternum and second rib left, 887
Testicle, calcification of vaginal sheath of (abs), 788
Tetanus and lesions of spine in childhood (abs), 939
Tetany in an adult (abs), 156
Thompsons, physicists and engineers, debt of radiology to, 409
Thomsons, physicists and engineers, debt of radiology to, 409
Thoracotomy for acute postpneumonic empyema, causes of failure of lung expansion following, 178
Thorotrast, experimental sarcoma production by (abs), 320
Thorax, right, accessory stomach in (abs), 154
roentgenograms of, and intracutaneous tuberculin test for adults (abs), 925
spontaneous arteriovenous aneurysms of (abs), 151
value of proper interpretation of lipiodol bronchograms in surgery of, 530
Thorium dioxide, fixation of, in inflamed tissue (abs), 801
hepatosplenography with, should it be completely abandoned? (abs), 467
rate of removal of, from blood stream (abs), 320
use of, in roentgenography of sinuses, 680
Thrombi, mural, roentgen diagnosis (abs), 927
Thymus gland, problem of, in children (abs), 923
radiology's responsibility in diagnosis and treatment of hyperplasia of (abs), 922
Thyroid deficiency in twins (abs), 924
tumor of humerus without demonstrable goiter (abs), 937
Thyroid gland, carcinoma, results of supervoltage roentgen therapy in, 586
main indication for radiation treatment of (abs), 479
malignant lesions of (abs), 800
roentgen therapy of, in treatment of cardiac decompensation (abs), 314
Tibia, pseudofracture of (abs), 470
Tissue, inflamed, fixation of thorium dioxide in (abs), 801
Tongue, carcinoma, results of supervoltage roentgen therapy in, 586
carcinoma, treatment of glandular metastases in (abs), 477
Tracheobronchitis, acute, diagnosis of, 333
Trauma, chronic, fatigue manifestations of scaphoid bone from (abs), 474
Tuberculin, sequence of roentgen evidence of tuberlosis and cutaneous sensitivity to (abs), 784
test, intracutaneous, for adults, and roentgenograms of chest (abs), 925
Tuberculosis and cutaneous sensitivity to tuberculin, sequence of roentgen evidence of (abs), 784
chronic pulmonary, changes in size and shape of heart shadow in (abs), 927
gastric, roentgen study, 59
incidence of pulmonary and extrapulmonary, in anthracite coal miners (abs), 926
of major bronchi, clinical recognition of (abs), 924

of pubis, roentgen pictures during course of (abs), 941
stenotic, of jejunum (abs), 930
Tumor, benign giant cell, of bone, five year cure, 884
of hypophysial duct (abs), 149
thyroid, of humerus without demonstrable goiter (abs), 937
Tumors, benign vascular, of parotid region, treatment with radium moulage (abs), 314
cortical and medullary adrenal, modified air injection roentgen technique for demonstrating (abs), 933
effect of experimentally formed, on musculoskeletal system of rat (abs), 320
intrabronchial and intrathoracic, 530
malignant, general and indirect effects of roentgen rays and their importance in treatment of (abs), 801
malignant, importance of retroperitoneal lymph nodes in (abs), 159
malignant, of small intestine (abs), 786
malignant, of thyroid gland (abs), 800
mediastinal, kymography as aid in differential diagnosis of (abs), 928
occurring in apex of lung, origin of, 838
xanthomatous, of joints (abs), 790
Twins, thyroid deficiency in (abs), 924

Ulcer, duodenal, in children (abs), 785
of distal end of first portion of duodenum and extrabulbar duodenal ulcer (abs), 785
of greater curvature of stomach, roentgen contribution to study of (abs), 928
prepyloric and carcinoma (E), 288
Ulcerative lesions of stomach and duodenum, diagnostic errors in, 48
Ultraviolet rays, studies of sensitizing action of tar preparations on skin irradiated with (abs), 803
Undulant fever, vertebral lesions in (abs), 790
United States Navy, examination for appointment as commissioned officers in Medical Corps of, 140
Ureteropyelography, unusual case of transparent intrauretero-pelvic calculus in (abs), 932
Urethra, carcinoma, radiation therapy (abs), 309
Urinary calculi, cystine, roentgen study of, 537
Urography, intravenous, can it be considered a test of renal function? (abs), 932
Urologic and abdominal lesions, problems in differential diagnosis between (abs), 796
Uterus, carcinoma, and ovarian function (abs), 481
carcinoma, results of supervoltage roentgen therapy in, 586
carcinoma, results of treatment (abs), 318
cervix, advanced carcinoma, with involvement of efferent urinary passages, fractional roentgen irradiation (abs), 317
cervix, carcinoma, individual radium treatment of (abs), 316
cervix, carcinoma, results of supervoltage roentgen therapy in, 586
cervix, carcinoma, significance of radiation reaction in (abs), 641
cervix, carcinoma, treated by roentgen and radium radiation (abs), 799
cervix, squamous cell epithelioma, with bone metastasis, 579

Vagina, sarcoma, therapy of (abs), 482
Vaginal sheath of testicle, calcification of (abs), 788
Vallecula, carcinoma, therapy of (abs), 316
Vegetative nervous system, irradiation of, in intermittent arteriosclerotic dysbasia (abs), 160
Veins, vertebral, function of, and their rôle in spread of metastases (E), 620
Ventriculography, frontal puncture for (abs), 149
Vertebrae, lesions of, in undulant fever (abs), 790
primary pyogenic osteomyelitis of articular processes of (abs), 470
Vertebral veins, function of, and their rôle in spread of metastases (E), 620
Virginia Radiological Society, 457
Vitreous, calcification of (abs), 921
Vocal cords, carcinoma of (abs), 478

Xanthomatosis, 396; (abs), 934
Xanthomata of joints (abs), 790
Xiphoid process of sternum, bifurcated and abnormally long (abs), 465

AUTHOR INDEX TO VOLUME 44

Abbott, W. Osler, 154
Abele, Adolf, 803
Ackermann, Alfred J., 59
Adams, W. E., 152
Agati, Dino, 936
Albright, Fuller, 775
Anderson, Bert G., 150
Anderson, Margaret, 789
Andreesen, Remmer, 474
Anspach, William E., 794
Anzilotti, A., 476, 929, 930, 932
Archer, Vincent W., 108
Armstrong, Eugene L., 151

Baccaglini, M., 928
Bacon, Ralph D., 71
Bade, Heinz, 319, 322, 801
Bailey, Frank R., 113
Barany, Elma, 579
Barber, C. Glenn, 793
Barbieri, Arrigo, 466, 787
Barnard, Leonard, 155
Barr, Joseph S., 774
Barth, E. E., 644
Batt, Richard C., 940
Batts, Martin, 470
Bauer, Walter, 775
Bean, William B., 152
Becker, R. F., 644
Belanger, George, 771
Belli, M., 464
Benassi, Enrico, 467, 788
Bennett, George E., 157
Bennett, Granville A., 775
Berg, J., 468
Bering, Fr., 641
Berk, Louis H., 927
Bertelotti, L., 802
Bianchini, A., 480
Bignami, Carlo, 795
Bignami, Giuseppe, 785, 786, 787, 794
Bishop, W. A., Jr., 790
Blackett, C. W., 774
Blades, Brian, 530
Bode, H. G., 477
Bolker, Herman, 98
Bonomini, Bruno, 784
Bracher, George J., 197
Bradford, F. Keith, 790
Broders, Albert C., 800
Bronk, Detlev W., 916
Brown, Percy, 409
Brunetti, Lodovico, 644
Brunschwig, Alexander, 83, 89
Buisson, M., 932
Burman, Michael, S., 37
Businco, Ottavio, 474

Cahal, Mac F., 296, 771, 912
Calchi-Novati, G., 643
Campbell, Lloyd A., 250, 263, 264
Cantarow, Abraham, 938
Cardillo, Furio, 944
Carty, John R., 248
Casati, Annibale, 783
Case, James T., 485
Caulk, Ralph M., 772
Cave, Edwin French, 472
Chamberlain, W. Edward, 638, 771
Chandler, Fremont A., 90
Chaoul, H., 311
Charr, Robert, 709
Charteris, Alexander A., 737
Chester, Edward M., 552
Chester, William, 552
Chodoff, Richard J., 154
Christensen, Helge, 918
Christophe, Kenneth, 473
Cignolini, Pietro, 484, 934
Clark, H. Chandler, 37
Cleaves, Edwin N., 937
Cloud, R. W., 610, 615
Cobey, Milton C., 157
Cockerell, T. D. A., 457
Codecà, Giovanni, 941
Coggin, Charles B., 151
Cohen, Abraham G., 924
Cohen, Archibald C., 926
Cole, George C., 925
Cole, Lewis Gregory, 772
Cole, William Gregory, 772
Coleman, Mark, 156
Collens, William S., 916
Collier, D. R., 386
Colosimo, Cesare, 465, 929
Compton, Arthur H., 270, 286
Cooke, Robert A., 680
Cooper, George, Jr., 108
Cope, Oliver, 933
Corrigan, K. E., 776
Cottenot, P., 635
Cova, Pier Luigi, 643
Crawford, J. Hamilton, 466
Crego, C. H., Jr., 791
Cushing, Harvey, 914

Daigger, A., 315
Dall'Acqua, V., 464
Dandy, Walter E., 148
Davenport, C. B., 665
Davenport, Lowry F., 772
Davidoff, Leo M., 1
Davis, Kenneth S., 144
Delherm, L., 636
Dell, J. M., Jr., 776
Derbyshire, A., 776
De Santo, Dominic A., 790
Desjardins, Arthur U., 126, 159, 594
Deutschmann, W., 637
Dick, Vernon S., 161
Dickson, Frank D., 937
Dietrich, Harry F., 939
Diveley, Rex L., 937
Dobelle, Martin, 789
Dörr, H., 469, 475
Dowell, D. Arnold, 776
Dresser, Richard, 776
Dulin, J. W., 154
Dyke, Cornelius G., 1, 771

Edeiken, Louis, 884
Ehrlich, William, 149
Eley, Clayton W., 626
Engelstad, Rolf Bull, 307
Epifanio, Giuseppe, 801
Epstein, Bernard S., 704
Erba, Lino, 922
Erdélyi, Josef, 159
Erlanger, Joseph, 916
Escudero, Lucilo, 152
Evans, William A., Jr., 714

Failla, G., 649, 889
Farber, Sidney, 776
Fariñas, P. L., 370, 773
Farrell, John T., Jr., 709
Fellowes, O. N., 115
Ferciot, C. Fred, 472
Ferris, Henry W., 942
Fisher, J. W., 772
Flocks, Rubin, 115
Flynn, James M., 69
Focht, Elizabeth F., 776
Forbes, Alexander, 916
Franklin, R. Maxwell, 152
Freedman, Eugene, 48
Fricke, Robert E., 263, 269
Fried, Carl, 401
Friedell, H. L., 805
Frisch, Ernst, 160
Fugazzola, Franco, 929

Gaini, Giuseppe, 476
Gal, Felix, 481, 482
Gallavresi, Luigi, 784
Gauss, C. J., 481
Garden, Robert S., 474
Garland, L. H., 805
Garvin, Curtis F., 151
Gasser, Herbert S., 916
Ghormley, Ralph K., 796
Gilardoni, Arturo, 484, 944

Gillespie, James B., 938
Gilmer, William P., 459
Gilmour, John, 158
Giordano, Giovanni, 643, 926
Glauner, R., 315
Goecke, H., 318
Goehring, Harrison D., 48
Goldberg, Benjamin, 207
Golden, Ross, 325, 773, 913
Gomez, Gonzalo Esguerra, 145
Goodman, B. A., 153
Gradoyevitch, Borivoye, 473
Gray, J. H., 158
Greene, Jesse J., 158
Gregori, Angelo, 319
Greineder, K., 311
Grier, G. W., 772
Gross, Sidney W., 149
Grove, R. Clark, 680
Guarini, Carlo, 934
Gubner, Richard, 466
Guidotti, Carlo, 931
Günsel, Eberhard, 943
Guthmann, H., 475

Hall, E. Walter, 623
Hall, R. D. McKellar, 936
Hall, Wendell C., 838
Ham, Donald P., 777
Hamann, Anna, 276
Hamblen, E. C., 143
Hamby, Wallace B., 636
Hampton, Aubrey O., 940
Hare, Hugh F., 775, 776
Hargrave, Robert, 800
Harrington, H. L., 320
Hasley, Clyde K., 922
Hayden, Henrietta, 776
Healy, T. R., 774
Heeren, J. G., 468
Heim de Balsac, R., 635, 834
Helwig, Ferdinand C., 937
Henderson, S. G., 772
Henderson, W. R., 148
Hendrickson, Herman S., 151
Herčik, Ferd., 803
Heupke, W., 145
Higgins, Charles C., 155
Hill, J. M., 772
Hintze, Arthur, 475
Hirsch, Edwin F., 383
Hochberg, Lew A., 153, 178
Hodges, Fred J., 866
Hodges, Fred M., 630
Hoerr, Stanley O., 795
Holinger, Paul, 384
Horvath, Joseph, 313
Horwitz, M. Thomas, 157
Horwitz, Thomas, 938
Hosen, H., 924
Howes, William E., 98, 106
Huber, Herbert, 308
Huepel, Robert C., 794
Hufford, C. E., 774
Huggins, Charles, 320
Hunt, Howard B., 254
Hunt, Luke W., 925

Inouye, K., 318
Irsik, Josef, 159

Jacobsen, Victor C., 235
Jacox, Harold W., 113
Jaffe, Henry L., 641, 799
James, H. H., 104

Kaplan, Ira I., 265, 636
Karshner, Rolla G., 939
Kazanjian, V. H., 789
Kellogg, Douglas S., 396
Kelly, James F., 776
Kernohan, James W., 149
Kerr, H. Dabney, 88, 115
Keys, Ancel, 805, 833
King, Don, 940
King, Donald S., 772
King, J. B., 922
King, Jennings M., 113
Kirchhoff, Heinz, 317
Kirklin, B. R., 357, 423, 774
Kirmse, T. W., 924
Kirshbaum, J. D., 716
Kliegel, Hubert, 477
Klusáková, M., 803
Knierer, W., 483
Knies, Phillip T., 230
Koehler, Hans, 803
Körbler, Juraj, 479
Kornblum, Karl, 333, 775
v. Kovesligethy, Ivan, 309
Kowarschik, J., 145
Krause, George R., 719
Kretschmer, Herman L., 796
Kühnau, J., 145
Küntscher, Gerhard, 319
Kuhlmann, F., 145
Kuhns, John G., 939
Kulowski, J., 793
Kunkel, Paul A., 148

Lampert, H., 145
Langendorff, H., 323
Lapidari, Mario, 917
Laquerrière, A., 636
Laubry, Ch., 635
Lauro, Armando, 937
Leader, Leonard O., 207
Lederer, Max, 153
Leef, Edward, 940
Leigh, Octa C., 773
Lenz, Maurice, 105
Leucutia, T., 586
Levene, George, 771
Levine, Milton I., 784
Levinson, Louis J., 303
Levyn, Lester, 203
Lewis, Raymond W., 170
Lincoln, E. M., 924
Lipschutz, Benjamin, 154
Livingston, S. K., 887
Loepp, W., 472
Logan, Myra, 157
Lorente de Nó, Rafael, 916
Love, J. Grafton, 149
Lovotti, S., 932
Lowry, Tom, 154
Lura, Antonio, 927
Luther, Wolfgang, 322

McAneny, John B., 747
McCarroll, H. R., 791
McClelland, J. E., 921
McGuire, Johnson, 152
Maderna, Candido, 642
Madrazo, M. F., 805
Margolies, Alexander, 150
Marinelli, L. D., 889
Marks, Joseph H., 732, 777
Marquis, W. James, 858
Martin, Charles L., 106, 263
Martinet, René, 785
Marzocchi, Gualtiero, 931
Mass, Max, 716
Massari, Gian Maria, 931
Master, Arthur M., 144
Mayoral, A., 943
Medinger, Frederick G., 786
Meigs, Joe V., 641, 799
Meisels, Emil, 564
Meland, Orville N., 105
Mendl, Karl, 31
Meyer, A., 928
Meyerding, Henry W., 800
Meyers, Frank, 203
Michael, Paul, 155
Milch, Henry, 792
Mitchell, A. Graeme, 923
Miyamoto, Sigeyuki, 320
Moehlig, Robert C., 17
Moller, P. F., 935
Moore, Sherwood, 24
Moorman, Lewis J., 154
Morrison, Harvey R., 537
Mucchi, Ludovico, 785, 917
Müller, Walther, 472
Murphy, John T., 774
Muscettola, Guiseppe, 932
Myers, Dan W., 530

Nathan, Louis, 939

Nathanson, Ira T., 799
Neil, R. H., 117
Nesbit, Reid M., 161
Neuhof, Harold, 684
Neumann, Werner, 311
Newell, Edward T., Jr., 307
Nicotra, Antonino, 934
Nuzzo, Luciano, 930

O'Brien, Frederick W., 105
Oberdoerffer, M. J., 386
Olds, John W., 357
Orndoff, Benjamin H., 600
Orsenigo, Serafino L., 788
Ostrum, Herman W., 726
Oughterson, A. W., 105

Pagani, A., 313
Pagel, W., 153
Paleari, Antonio, 921
Papperitz, W., 323
Parsons, Phillip B., 175
Pearson, Manuel M., 726
Peck, Nathan, 303
Peck, Willis S., 866
Peirce, Carleton B., 848
Pellegrini, G., 314
Pemberton, John de J., 800
Perkins, Charles W., 773
Perlman, H. H., 935
Perona, Pietro, 144
Peterson, F. R., 154
Peterson, Leonard T., 483
Peukert, Lothar, 803
Pfeifer, Walter, 477
Pfeiffer, Raymond L., 558
Phemister, Dallas B., 791
Picchio, Carlo, 794
Piccolo, Giacinto, 801
Pierson, Edward L., 777
Platt, Louis, 175
Pohle, Ernst A., 747
Pollock, George A., 796
Pomerantz, Leo, 320
Ponzio, Mario, 310
Porta, Virginio, 917
Portmann, U. V., 874
Possati, Alberto, 307
Pulvertaft, R. Guy, 788

Quigley, Daniel T., 110
Quimby, Edith H., 105, 776

Rabin, Coleman B., 684
Ransom, Henry K., 866
Ratti, Arduino, 465, 469
Reding, R., 797
Reeves, Robert J., 772
Reichenmiller, Hans, 316
Reimann, Hobart A., 333
Reimann, Stanley P., 444
Renfroe, Olive, 665
Reynolds, L., 383, 776
Rhinehart, Barton A., 635
Richards, Gordon E., 776
Rigler, Leo G., 634, 805
Roberts, Sumner M., 470
Robinson, J. Maurice, 601
Robinson, Walter W., 774
Rocchini, G., 643
Roesler, Hugo, 773
Rothberg, Abraham S., 471
Routier, D., 635, 834
Rouvière, H., 916
Rowbotham, G. F., 149
Rubenfeld, Sidney, 265, 636, 875
Rüsken, Wilhelm, 798
Runco, Antonio, 794, 938
Ryerson, Edwin W., 96

Sala, Angelo M., 579
Santagati, Francesco, 782
Sante, L. R., 350
Saxl, Otto, 31
Schaefer, W., 308
Schatzki, Richard, 773, 933
Schenck, Samuel George, 568
Schinz, Hans R., 478
Schittenhelm, A., 479
Schlesinger, M. J., 773
Schreiber, Frederic, 17
Schulte, G., 145
Schulz, M. D., 644
Schwartz, Charles Wadsworth, 188
Scott, Wendell G., 832
Scupham, George W., 851
Secomandi, Giov. Maria, 787
Severance, Alvin O., 641
Shehadi, William H., 470
Shelden, C. Hunter, 149
Siciliano, L., 308
Siegel, Mortimer L., 151
Siegling, John A., 938
Simmonds, F. A. H., 153
Simon, Harold E., 473
Simon, O., 310
Simonetti, C., 921
Singer, George, 428
Skinner, E. H., 664, 755
Sloat, J. L., 483
Smerchinich, Giovanni, 800
Smith, C. H., 924
Smith, David H., 158
Smith, E. J. Radley, 157
Smith, Wilbur A., 466
Snell, Dorothy, 789
Snow, William, 777
Sokoloff, Martin J., 709
Solis-Cohen, Leon, 785
Sontag, L. W., 789
Sosman, Merrill C., 645, 771
Spedini, F., 464
Spurling, R. Glen, 790
Steel, David, 592
Stein, Justin J., 469
Steinbach, Meyer, 785
Stenstrom, K. Wilhelm, 284
Stewart, Steele F., 939
Stone, Robert S., 601
Sugarbaker, Everett D., 756
Sugiura, Kanematsu, 756
Sussman, Marcy L., 345
Sutro, Charles J., 320
Sweany, Henry C., 209
Swenson, Paul C., 773

Taft, Robert B., 777
Talbott, John H., 775
Tarr, Leonard, 942
Tartagli, Dino, 782
Taylor, Fletcher B., 155
Taylor, Grantley W., 799
Taylor, Lauriston S., 428
Tempini, Giambattista, 643
Terwilliger, C. K., 940
Teufel, S., 315
Thaxter, Langdon T., 853
Thomas, Merthyn A., 778
Thomason, H. A., 943
Thoms, Herbert, 9
Toniolo, G., 321
Trivelli, Luciano, 793
Trump, J. G., 610, 615
Trump, John, 776
Tschetter, David, 83
Turano, Luigi, 483

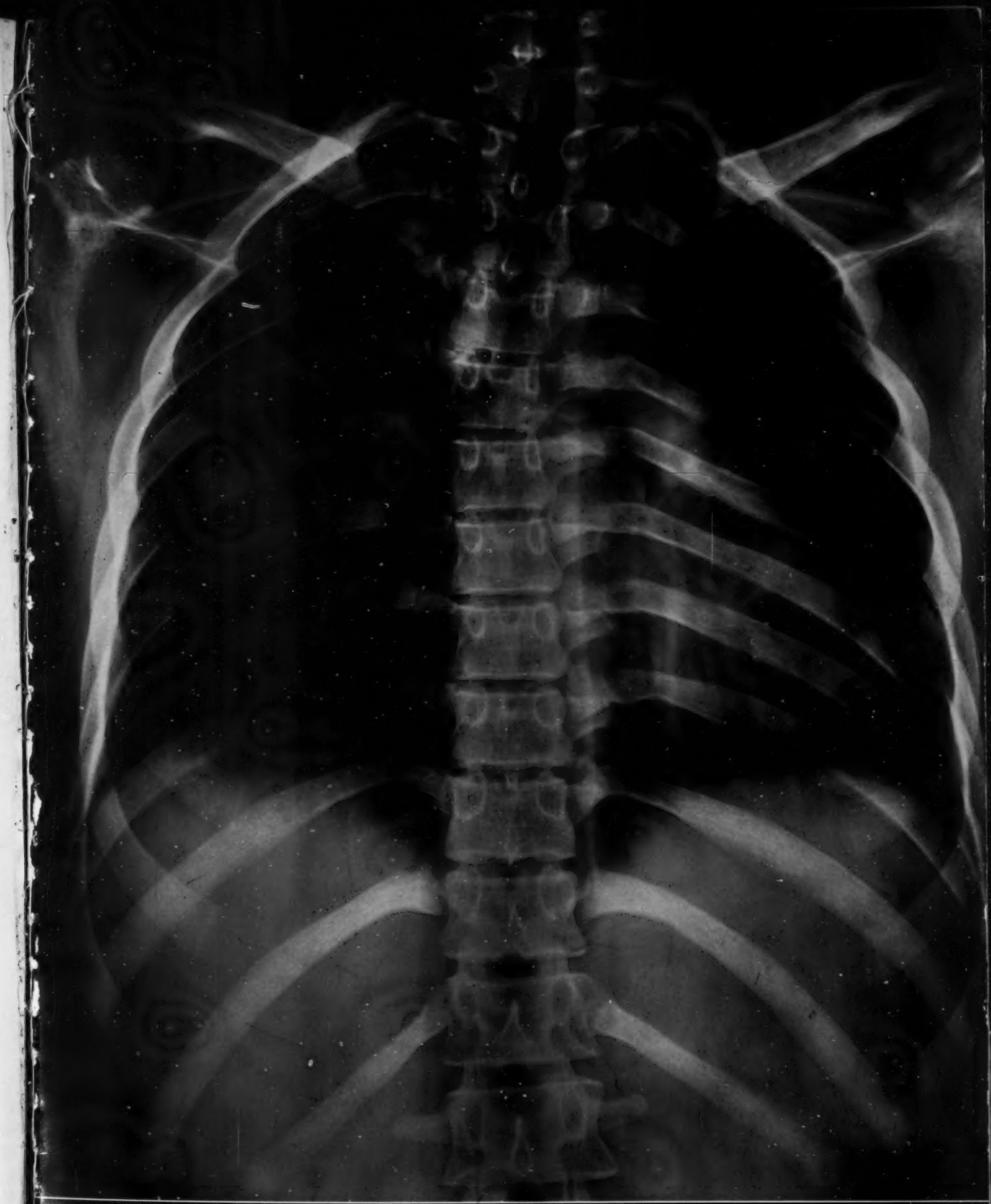
Ulrich, Helmuth, 941
Ungerleider, Harry E., 466

Valdini, P. L., 464
Valenti, Alessandro, 786
Van de Graaff, R. J., 610
Vidgoff, Ben, 197
Vitale, Emanuele, 783
Vogt, Edward C., 470, 771
Vonessen, A., 640

Wallace, William S., 772
Wallfield, Mark J., 784
Warkany, Josef, 923
Warner, A. H., 117
Warren, Shields, 641, 775, 795
Warren, Stafford L., 291
Weber, Harry M., 774
Wehr, W. H., 105
Wendlberger, J., 797
Wessely, Emil, 316
Wessler, H., 924

White, T. N., 889
von Wieser, W., 312
Wilensky, Nathan D., 916
Williamson, Bryn, 473
Wilson, Philip D., 790
Wilson, Stanley A., 777
Windle, W. F., 644
Wirth, John E., 263
Wörner, Eduard, 471
Wolferth, Charles C., 150
Wright, Louis T., 157
Wyatt, George M., 771, 776
Young, Barton R., 519, 638, 772

Zaffiro, Edoardo, 804
Zeman, F., 803
Zubiani, Giulio, 926



Reproduced from a radiograph made on

BLUE BRAND EASTMAN ULTRA-SPEED X-RAY SAFETY FILM

(Technical Factors on Back of This Page)

Technical Factors for Radiograph Reproduced on Reverse Side of This Page . . . .

POSTURE	**Supine**
PROJECTION	**Anteroposterior**
THICKNESS	**18 cm.**
ANODE-FILM DISTANCE	**40″**
P-B DIAPHRAGM	**8-1 grid-ratio**
TUBE FOCAL SPOT	**1.2 mm.**
PROTECTIVE FILTER	**.5 mm. aluminum**
FILM	**Blue Brand Eastman *Ultra-Speed***
SCREENS	**Eastman *Fine-Grain***
KV. P.	**70**
MA. S.	**160**
DEVELOPMENT	**Kodalk X-ray Developer (3½ min., 65° F.)**
FIXATION	**Eastman X-ray Fixer**

Blue Brand Eastman *Ultra-Speed* X-ray Film . . . Eastman *Fine-Grain* X-ray Intensifying Screens . . . Kodalk X-ray Developer Powders . . . Eastman Prepared X-ray Fixing Powders are made to complement each other. This combination in your laboratory will provide the best assurance you can buy of diagnostically excellent radiographs.

EASTMAN KODAK COMPANY

Medical Division—Rochester, N. Y.

(*See reverse side of this page*)

The sea sings a song of Christmas at

CHALFONTE-HADDON HALL

Neptune and Santa have planned a wonderful Christmas house party at these beachfront hotels. It will start Christmas Eve, with carols round the glowing Haddon Hall tree, and will continue with fun and feasting unabated for the whole holiday week.

Come, join in the jollity. Stockings for the youngsters, gifts for the grown-ups, your own family turkey. Concerts, dances, and a grand big party on New Year's Eve. Restricted clientele.

LEEDS AND LIPPINCOTT COMPANY
On the Boardwalk

Atlantic City

Write for color folder

Why

MIX POWDERS...AND WAIT
HEAT WATER...AND WAIT
LET COOL...AND WAIT

You don't

WITH URELL CONCENTRATED X-RAY SOLUTIONS

★ No answer to *all* your dark-room problems, Urell X-Ray Developer and Fixer Solutions will nevertheless reduce *to minutes* the long hours you've been spending mixing powders!

★ For here's all you do with Urell Solutions—*simply dilute and develop!* No measuring . . . no heating water . . . no standing around while solutions cool. Just add water—and start your films through.

★ Urell Solutions are the result of 15 years' experience in this field, and are as reliable, safe, and long lasting as solutions made of the finest powders. Results obtained are comparable in every way . . . ample densities . . . full shadow detail . . . excellent diagnostic qualities. Under test, nearly 120,000 square inches of film have been developed in one six-gallon Urell Solution with uniform results. The Urell Fixer will completely clear a 14 x 17 film in less than a minute, leaving no opalescence and insuring ample hardness to stand washing and drying.

★ X-ray technicians in leading laboratories everywhere are speeding up their darkroom work with Urell X-Ray Solutions. Why don't you? You'll not only save time, but money as well . . . for you pay *no premium* for the added convenience of getting work done easier and faster. Order from your dealer *today*.

DILUTE AND DEVELOP!

URELL CONCENTRATED LIQUID DEVELOPER		URELL CONCENTRATED LIQUID FIXER	
1 QUART CONCENTRATE (makes one gallon)	$ .85	1 QUART CONCENTRATE (makes one gallon)	$ .60
4 QUARTS CONCENTRATE (makes four gallons)	2.80	4 QUARTS CONCENTRATE (makes four gallons)	2.00

Urell Inc.

1414 N. VERMONT AVE., LOS ANGELES, CALIFORNIA

INTRA-CAVITY X-RAY THERAPY CONE

permitting sighting of lesion during installation and checking position during treatment.

INTRODUCED AT THE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY, CHICAGO, ILL.

Order thru your Dealer or direct from

H. B. ODMANN, Inc.
Mechanical Therapeutic and Diagnostic Specialities
Leonia, N.J.

RUSLANDER
EXHIBIT FRAME
•
Five Sizes in Three Styles

Ready to Use!
Film and caption slide into grooves. No pasting necessary. Slides can be changed. Fits convention booths and all interlock.
•
Send for price list
•
Westcott Paper Products Co.
2530 Fifth St., Detroit

FOR SPECIAL OFFER
ON
MANY BACK ISSUES AND COMPLETE VOLUMES
See pages xiv and xv of Advertising Section

M Where precision counts there are two essential *MUSTS* M

That a radiologist must have measuring equipment is an accepted fact—that these instruments must be inspected at regular intervals is a fact often neglected.

The instruments on an aeroplane, the precision gauges used in industry, the timer of the railroad engineer are all essential to safe operation. To maintain their accuracy and assure safety and precision these instruments are regularly inspected.

Possession is vital, calibration is equally vital.

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVE., CLEVELAND, OHIO

VOLUME 44 DECEMBER, 1940 NUMBER 6

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

Medical Library JAN 2 1941

The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

OFFICIAL ORGAN
THE AMERICAN ROENTGEN RAY SOCIETY
THE AMERICAN RADIUM SOCIETY

Editor: LAWRENCE REYNOLDS, M.D.

Editorial Board
A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR

Advisory Board for Pathology
JAMES EWING, M.D. EUGENE L. OPIE, M.D.

ISSUED MONTHLY FOR THE AMERICAN ROENTGEN RAY SOCIETY
BY CHARLES C THOMAS, PUBLISHER, SPRINGFIELD, ILLINOIS

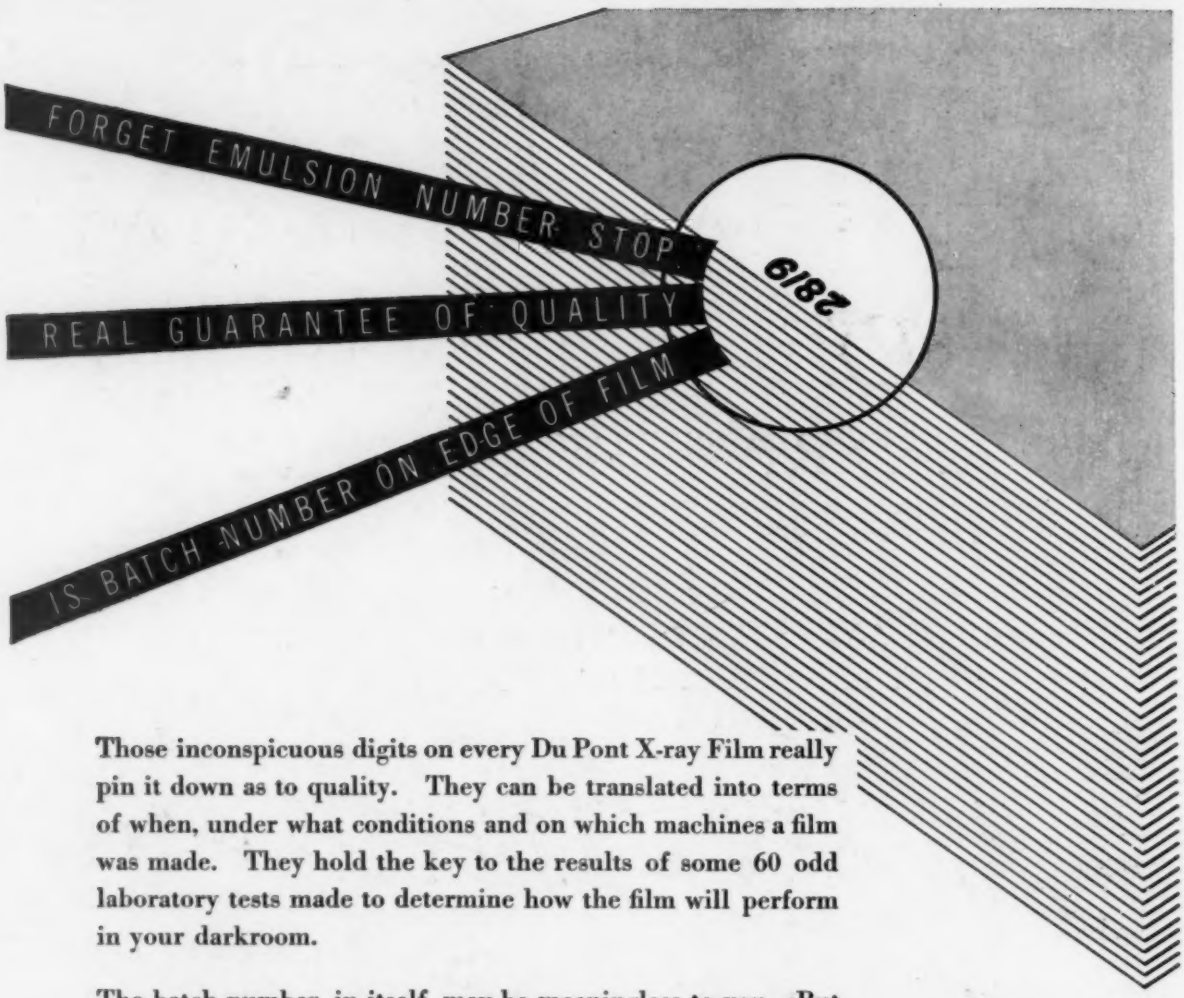
American Roentgen Ray Society · *Forty-second Annual Meeting*

CINCINNATI, OHIO, 1941

American Radium Society · *Twenty-sixth Annual Meeting*

CLEVELAND, OHIO, JUNE 2-3, 1941

YEARLY SUBSCRIPTION $10.00



Those inconspicuous digits on every Du Pont X-ray Film really pin it down as to quality. They can be translated into terms of when, under what conditions and on which machines a film was made. They hold the key to the results of some 60 odd laboratory tests made to determine how the film will perform in your darkroom.

The batch number, in itself, may be meaningless to you. But the mass of information it represents is your assurance that one box of Du Pont X-ray Film is exactly like another, that, regardless of size, every sheet has the speed and contrast to produce a fine radiograph. The precision with which quality can be controlled by this system of batch numbers accounts for the unerring uniformity of Du Pont X-ray Films. To produce excellent radiographs day in and day out, work with a film that is dependable — Du Pont Film. Like many other roentgenologists, you can take its quality for granted.

2 New Dental Films

DuPont D's (double emulsion) and Du Pont S's (single emulsion) are setting new standards of speed and contrast in dental radiography.

Their convenient PULL-A-TAB packets are easy to position and easy to open. Try a box on your next order.

X-RAY DU PONT FILMS

For Better Radiographs

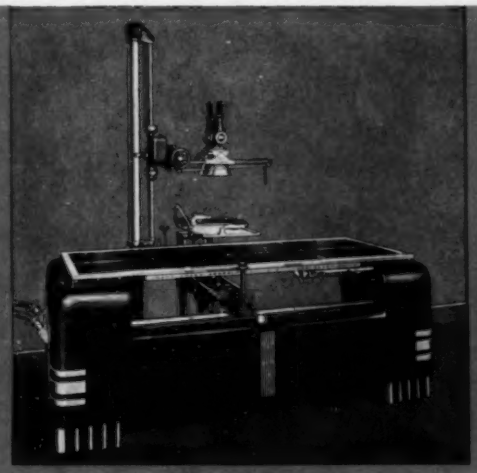
Du Pont Film Manufacturing Corporation, 9 Rockefeller Plaza, New York, N. Y.

RESPONSIVE TO THE ROENTGENOLOGIST'S SKILL

Keleket DIAGNOSTIC TABLE

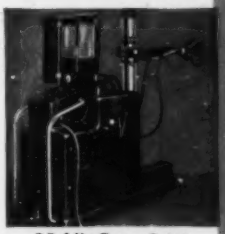
In this one compact piece of equipment Keleket combines fluoroscopic and roentgenographic facilities which greatly increase the operator's scope and ease in making diagnoses. For example, when an interesting pathological condition is noted in making a fluoroscopic examination, the roentgenographic tube may be quickly moved over the pathological area and an exposure made without moving the patient. Ask for bulletin explaining the flexibility, functions and construction of this apparatus, that by virtue of advanced usefulness and engineering merits the name Keleket.

Multicron
200 MA or 500 MA



Diagnostic Table

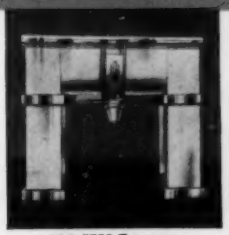
Keleket Kieffer
Laminagraph



Mobile Superficial
Therapy Unit

"KY" Mobile
Bedside Unit

Keleket
Techron



400 KV Superay

400 KV Constant Potential X-Ray Apparatus

200 KV
Masteray

THE KELLEY-KOETT MFG. CO. · X-RAY EQUIPMENT · COVINGTON · KENTUCKY · U. S. A.

~ THIS CHRISTMAS ~

when the candles are lit and the trees are hung with bright ornaments, the Spirit of Christmas will walk abroad in an America that is alive to the tremendous drama of today's History... an America whose people are bound closer than ever to each other by the sorrow of the nations across the seas. ☆ For our cherished gift of Freedom and for those we hold near and dear to us—we say in genuine humility...

Merry Christmas

James Picker